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Assessing the Quantified Impact of a Hybrid POGIL Methodology on Student Averages in a Forensic Science Survey Course

Tyna Lynn Meeks
Syracuse University

ABSTRACT

A causal-comparative/quasi experimental study examined the effect of incorporating a hybrid teaching methodology that blended lecture with Process Oriented Guided Inquiry Lessons (POGILs) on the overall academic achievement of a diverse student body in a large lecture setting. Additional considerations included student gender, ethnicity, declared major (STEM or non-STEM), and SAT scores. An evaluation of the effect that these characteristics had on student achievement due to differentiating import placed on the use of POGILs as a learning tool was included. This study used data obtained from a longitudinal examination of eight years of student data from an introductory forensic science survey course offered in a R1 northeastern university.

This study addressed the effectiveness of applying a proscribed active learning methodology, one proposed effective in collegiate education, to a new environment, forensic science. The methodology employed combined fourteen POGILs, created specifically for the chosen course, with didactic lecture during the entire semester of a forensic science survey course. This quasi-experimental design used the manipulation of the independent variable, the use of a hybrid lecture instead of exclusive use of traditional didactic lectures, on the students' academic achievement on exams given during the course.

Participants in this study (N=1436) were undergraduate students enrolled in the single semester introductory science course. A longitudinal study that incorporated eight years of data was completed, 4 years pre-intervention (2007-2010) and 4 years post-intervention (2011-2014). The forensic science survey course, taught by only one professor during the eight-year period, was a science discipline that had yet to integrate an active learning educational model.

Findings indicate four variables significantly contributed to explaining nearly 28% of the variation seen in the student class averages earned during the eight-year period: the intervention, gender, STEM majors, and SAT scores. On average, the intervention significantly altered exam scores, $F(1, 1431) = 43.019$, $p < 0.000$, $R^2 = 0.029$, raising exam averages 3.1%. Within the population, females outperformed their male counterparts by 1.9%, although both genders were significantly affected by the intervention, $F(1, 1431) = 13.698$, $p < 0.000$, $R^2 = 0.009$. Students with declared majors in the STEM fields outperformed the non-STEM fields by 5.6%, a strong factor in the model, $F(1, 1431) = 91.918$, $p < 0.000$, $R^2 = 0.060$, with both STEM and non-STEM students being positively affected by the intervention. The SAT scores, however, showed the strongest effect, $F(1, 1431) = 345.026$, $p < 0.000$, $R^2 = 0.179$, where an increase of 3.1% in the student class averages could be seen for every 100 points earned on the SATs. Further discussions include implications and correlations to recent research and directions for future research.

ASSESSING THE QUANTIFIED IMPACT OF A HYBRID POGIL METHODOLOGY ON STUDENT AVERAGES IN A FORENSIC SCIENCE SURVEY COURSE

By

Tyna L. Meeks

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DEDICATION

To Michael, you showed me my heart, and gave me the grace and strength of yours, along with patience, acceptance, and encouragement that never faltered.

To Devin and Zachary, the greatest accomplishment I will ever have is being your mom, you never gave up on me, you never complained, and you always showed me your love.

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CHAPTER ONE: Introduction

Pedagogy for Active Learning

Researchers have explored the pros and cons of various teaching methods that educators have used in the traditional collegiate science classroom over the last fifteen years. "Learning itself is not a process that insists on perfect understanding at every step… and learning in science, in particular, is a nonlinear sequence of observing facts, then trying to explain them, and in the process of gathering or being confronted with further facts [the student] is continuing to augment [his/her] understanding" (Hoffman and McGuire, 2010, p. 382). There has been an increased push to advance this learning process in a fruitful way, both qualitatively and quantitatively, using techniques that will help the student to create his or her own learning process. "For those charged with improving the quality of teaching and learning in universities, an abiding concern has been trying to persuade academics to shift from teacher-centred forms of teaching towards more students-centred approaches" (Kember, 2009, p. 1). For a variety of reasons, a more active pedagogy is driving increased numbers of educators in secondary and post-secondary sciences away from traditional faculty-centered, didactic lecture-based science education models.

Driving these changes are concerns over lower test scores among general science students and reports of decreased retention rates in upper level science courses, both of which may be partially attributed to educators' use of passive, less-engaging lessons. The focus of active learning strategies is on developing not only students' knowledge but also their skills and abilities by providing opportunities "to *talk and listen, read, write,* and *reflect* as they approach course content" (Meyers and Jones, 1993, p. xi). In response to the search for a successful active learning model, the Process Oriented Guided Inquiry Learning (POGIL) model evolved from cooperative learning models and peer-led team-learning models for the science classroom. The POGIL project, originally developed over twenty years ago for a general chemistry classroom at Franklin and Marshall College, is the combined efforts of John J. Farrell, Richard S. Moog, and James N. Spencer to improve chemistry education techniques by stressing process as well as content. Spencer *et al.* linked the POGIL project, constructivism, guided inquiry, and cooperative learning activities in secondary and post-secondary classrooms (POGIL, 2006a). As the project evolved, more educators actively trained in the use of POGILs through workshops and in the writing of new POGIL activities. Through the training, educators learned to create lessons specifically designed for their curricular level if activities did not currently exist. In the first twenty years, the number of colleges, universities, and high schools using the POGIL program climbed to over a thousand, but the activities and curricula involved were limited to those originally created for chemistry with minor branching efforts into biology, physics and business courses.

Generally, the POGIL educational materials included activities performed by small groups of students (4-5) that encouraged the students to build their own knowledge from a variety of models. Students took on one of four main roles: manager/student facilitator of the group, reader for the group, recorder/presenter of answers to questions, or reflector/quality control person responsible for seeking help and bringing that back to the group as needed (Hanson, 2006). As students had specific roles during the activity, so did the educator. The educator led the learning process by engaging the smaller groups, assessing group discussions for naive views, and monitoring the overall building of knowledge as they modified time spent on specific activities. Colleges and universities implementing the POGIL program sought greater mastery and higher grades than in traditionally taught students (POGIL, 2006b).

The POGIL program was originally declared effective using qualitative data obtained through multiple student interview-based studies demonstrating a positive aspect of utilizing the POGIL activity; however, no statistically relevant effect on student scores was shown (Shatila, 2007; Wozniak, 2012). These qualitative studies showed an increase in the perceived satisfaction of learning from the student perspective, an important advantage of employing an alternative, more active learning methodology in the large lecture hall. Quantitatively, however, only a few studies before 2010 reported that POGIL participants earned higher assessment ratings due to the use of the POGIL activity. Additional studies published between 2010 and 2014 quantitatively demonstrated the positive effect POGILs were having on small classroom chemistry courses as well as a more diverse set of subjects, including aviation, psychology, and foreign language. Although a positive trend appeared to be growing in POGIL use, these results appeared inconclusive when applied to a larger lecture setting due to limitations inherent in increased classes with over 70 students.

As emphasized by the original authors, Spencer, Moog, and Farrell, POGILs remained firmly rooted in the chemistry curriculum in the smaller class setting, 25 students or fewer per section (POGIL, 2006b). Few assessments reported the use of POGILs in large lecture environments, where a majority of undergraduate science instruction actually takes place, and none in the field of forensic science. Although advocates advertised POGIL activities as broadband solutions to help high school and collegiate educators bring active learning into the classroom to create a more effective learning environment for the student, the proscribed method seemed confined to specific courses and class sizes. Before 2010, the lack of quantitative proof of improved student academics in lecture hall settings outside of the chemistry arena suggested limitations to the incorporation of active learning strategies in these larger settings. In an educational environment where test scores have become a leading measure of teacher effectiveness, the question, 'how could the effectiveness of a science educator be increased?' resonates among educators.

Why Forensic Science?

The overall effectiveness of science educators was important to consider, but why the need to incorporate active learning methodologies to forensic science instruction? "The turn of the century has witnessed an explosion of forensic programs offered by academic institutions worldwide…" (Tebbett *et al.*, 2007, p. 62). Many factors contributed to this 'explosion' of interest, foremost the popularity of fiction and nonfiction television shows like *CSI*, *NCIS*, and *Forensic Files*. Many universities and colleges began to add "Forensics" to course titles, attempting to ride the popularity wave while encouraging students to enroll in "hard science" courses. The more creative the course title, the more tenuous the connection to forensic science seemed to be, and a problem developed as students with inadequate science backgrounds enrolled in advanced forensic science courses. To prevent further problematic developments, "the American College of Forensic Examiners took the necessary steps to make a vast improvement in maintaining and enhancing the quality of traditional science education through its new program, The Commission on Forensic Education" (Tebbett *et al.*, 2007, p. 63).

Forensic science courses offered through accredited universities required science educators assigned to these courses to have expertise in multiple fields and disciplines as well as the ability to develop multiple teaching strategies. A broad spectrum of non-science majors taking forensic science classes based on media-inspired interest necessitated the exploration of alternative methods. Active learning, beyond required laboratories, offered the forensic science educator an additional way to utilize the media hype in the filed to generate interest in the science underpinning forensic techniques. The quality of the classroom instruction provided by an educator relies on the instructor's ability to offer multiple teaching styles to a diverse student population, and an active learning lesson enhances the educator's ability to reach a wider range of students.

Analyzing Which Student Descriptors?

Acknowledging the range of skill sets and general science backgrounds seen in a given student population, specific student characteristics were closely examined to look for correlations related to changes in exam scores. "When reform evaluations consider only the 'generic student' without attention to which groups of students might preferentially benefit and which might be disadvantaged, overall effectiveness can be a misleading measure" (Lewis and Lewis, 2008, p. 795). Significant research followed to understand the relationship between external factors such as time constraints, preparation of educator, alignment with curricula and the roles of the facilitator and student and their effect on active learning lessons. "However, given the role of group participation required for a successful [active learning environment], factors influencing the interplay of individuals within the small group influence the overall learning process and outcomes" (Khan and Sobani, 2012, p. 122). Among the factors that influence the overall learning process, the four factors studied in our research are gender, ethnicity, science background (Science, Technology, Engineering & Mathematics vs. non- Science, Technology, Engineering & Mathematics majors), and foundational knowledge levels (SAT scores).

Multiple studies have examined the use of active learning strategies, particularly problem based learning activities, such as POGILs, on small groups deliberately organized by gender. "Findings have been reported across literature suggesting that males and females possess different styles of thinking, learning, and have different approaches to problem solving" (Khan and Sobani, 2012, p. 123). When reviewing examination scores, few differences between the homogenous groups based on gender were observed. Female groups were found to exhibit higher productivity, motivation, interaction among group members, listening, and information sharing. A difference in the type of facilitator, peer or instructor also affected the homogeneously grouped students, with males preferring a peer leader and females an instructor. Other gender effects researched included trust of information provided in a group setting, enjoyment of active learning lessons themselves, and reasons for knowledge learning (internalized knowledge versus learning enough to get through the exam).

"Gender, race, and ethnicity may also influence levels of active participation within cooperative groups; Dornyei *et al* pointed out that leadership, decision making, trust building, communication, and conflict management skills need to be inculcated into participants in order to achieve the objective of cultural sensitization" (Khan and Sobani, 2012, p. 124). Groups of heterogeneous ethnicity saw initial problems develop as the students learned to incorporate essential skills needed for cooperative learning. Active learning lessons attributed to "enhanced cross-ethnic socialization, resulted in improved interpersonal dynamics and effective learning amongst students. This fact is further supported by Singaram *et al* who concluded that small groups from diverse backgrounds can help in overcoming social barriers amongst students and allow collaborative learning amongst them" (Khan and Sobani, 2012, p. 124). Alternatively, researchers found that group work promoted status [ethnic] differences, with majority students viewing minority students as less competent (Cohen, 1991). Such inconclusive research results led to the question of ethnic effects upon successful completion of examinations using active learning lessons.

The other two factors considered as potential student factors, STEM and SAT scores, are often related. “It is recognized that gaining scientific knowledge is especially difficult for students. Inefficient formal lectures, which are the most common vehicle to disseminate information, and large class sizes usually serve to estrange the struggling student from the instructor…Math SAT scores are traditionally used to identify students with an aptitude in science and math-related courses” (Bunce, 1993, p. 183). This research utilized SAT scores as the baseline for foundational education and study skills, while separately looking at the declared majors of students. Although related, the two separate factors treated independently allowed the identification of any correlations in one or the other. Previous research examined the effect of STEM declared majors: “student’s perception of science literacy enhances our understanding of their motivation to become science literate” (Holden, 2012, p. 108). This led to the question of whether a student who identified as a STEM major, or science/math literate, could be identified as a student better equipped to learn science. If the STEM major is identified as better equipped to study science/math, does the passive or active lesson play any difference in their exam scores?

Statement of the Problem and Research Questions

The National Research Council (2007) criticized a typical science educator that only used “passive and narrow views of science learning or an activity-oriented approach devoid of question probing” (p. 254). The POGIL project attempted to approach this problem by creating activities with a model of deliberative guided questions, higher-level problems, and application of skills. Although twenty years has passed since the advent of the POGIL project at Franklin and Marshall College, and over a thousand high schools, colleges, and universities began incorporating the POGIL project, the large private university where this study took place was not one of the universities that adopted this method. The Department of Chemistry at the private university chosen for this study, using the POGIL project as a template for newly created lessons, incorporated a series of active learning exercises blended with lecture into the forensic science survey course. The POGIL template exclusively used for the creation of the active learning lessons developed in our work was hoped to enhance the chosen methodology of teaching and considered post-intervention. These modified lessons incorporated a mixture of didactic lecture and the prepared POGIL active learning lessons each week. The designed POGIL activities ran between 25 - 45 minutes in length and we explored the possibility of using a mini lecture as the introductory model.

Previous published studies implied the acceptance of the POGIL methodology by the students to be relatively smooth, given the positive feedback. Although abundant research examined qualitatively the effect of the POGIL active learning methodology on student views, few studies quantitatively showed how they affected student scores in the large lecture environment, and none attempted to incorporate the POGIL model in the forensic science curricula. Examination of student diversity as related to the effect of active learning on achievement scores potentially allowed for the possible identification of student descriptors most influenced by an active learning environment.

The purpose of our causal-comparative/quasi-experimental study was to quantify the effect of blending the use of active learning activities, POGILs, with a standard lecture format in a forensic science large lecture survey course. A single professor had taught for many years the forensic science course, one section per year, using a didactic lecture model only. During the study, the instructor adopted a mix of didactic lecture and course designed POGILs. We assessed the effect of this change by looking at the changes in assessment scores due to POGIL incorporation. Exam scores considered in this study included those taken throughout the semester, specifically three hourly exams and the final exam. The student descriptors considered that might influence the intended use of the POGIL activity included gender, ethnicity, major declared by the student, and SAT scores. These descriptors may also cause a student to place more trust in the activity or to be more receptive to working in groups as a learning strategy. If these descriptors aid in the intrinsic investment of a student in active learning, value exists in being able to predict learning strategies based on the student population in a course.

The specific research questions asked in this study were:

1. Was there an overall effect of using an active learning intervention on student class averages?
2. Was there an effect on student class averages due to active learning intervention when controlling for gender?
3. Was there an effect on student class averages due to active learning intervention when controlling for racial identity/ethnicity?
4. Was there an effect on student class averages due to active learning intervention when controlling for STEM vs. non-STEM declared majors?
5. Was there an effect on student class averages due to active learning intervention when controlling for SAT scores?
6. When considering all of the variables simultaneously, which remain significant predictors of student class averages?

Summary of Chapter One

This study will determine the impact an active learning hybrid methodology has on objective student class examination averages by identified groupings. The Next Generation Science Standards (NGSS) called for an increased use of active learning lessons in science courses, and researchers have based many attempted pedagogies on constructivism, a philosophy of learning founded on the premise that, by reflecting on personal experiences, learners can construct their own understanding of the world. A noticeable reluctance, based upon several limitations, kept many professors from applying these non-traditional methodologies, yet replacing a single didactic lecture with a student-centered teaching approach each week was purported to be a worthwhile investment for the right educator with the right skill set. A modification of some of the lectures into active learning lessons could also support the qualitative studies that showed such an approach of incorporating active learning led to deeper student learning (Trigwell and Prosser, 2004) as well as providing a higher level of personal satisfaction for the students and instructor.

In our work at a large, private university, we specifically tried to the hybrid class format incorporating active learning strategies in a foundational survey course, Introduction to Forensic Science. Diverse students often take this course as the physical science with lab requirement for the students' liberal arts requirement. This study evaluates the effectiveness of using POGIL materials created exclusively for the forensic science course. The following statement represented the crucial rationale for designing and conducting this study. If an educator believes that: (a) their efforts to create and implement an active learning lesson, similar to those created through the POGIL project, will lead to higher achievement scores, then (b) a larger number of science educators still using didactic lecture will begin to actively seek alternate teaching methodologies best suited to the typical student enrolled in their course.

Organization of the Study

The following provides a summary of this dissertation. Chapter One provides the core rationale for this study by highlighting active learning pedagogy, its potential value in introductory science courses such as forensic science, and an introduction to the student characteristics examined as potentially associated with the use of the intervention. It situates the study within the present era of teacher accountability and the role of collegiate professor as an educator to diverse populations utilizing active learning methodologies.

Chapter Two includes a review of literature on the development of active learning and authentic learning environments. It highlights the ideological and practical challenges inherent in the incorporation of active learning. It also reviews empirical research investigating the use of active learning in the collegiate classroom and further explores the diverse student characteristics considered when developing active learning lessons. Finally, it connects the conceptual model of this study to the research questions.

Chapter Three includes information on the design and methodology used in this study. It provides detailed information of the variables used in the study and methodological decisions.

Chapter Four presents the results and analysis of the study, including how to interpret the findings within the context of this research.

Finally, Chapter Five consists of the discussion of the findings, the strength, and limitations of the study and future recommendations.

Definition of Terms

- CHE113 – Forensic Science survey course offered by R1 Northeastern University
- IRB – Institutional Review Board
- MID – Multi Initiative Dissemination
- NSES – National Science Education Standards
- OIRA – Office of Institutional Research and Assessment
- PLGI – Peer Led Guided Inquiry

- PLTL – Peer Led Team Learning
- POGIL – Process Oriented Guided Inquiry Learning
- STEM - Science, Technology, Engineering, and Mathematics
- R_1 – Research University

CHAPTER TWO: Literature Review

This study is built on and hopefully extends the literature on active learning lessons based on the constructivism theory of learning and cooperative learning as it applies to the science learner. The intervention employed in this study followed the proscribed active learning approach designed by the Process Oriented Guided Inquiry Lesson (POGIL) project. Using the POGIL template, this study blended course specific authentic learning activities with a didactic lecture format to modify the introductory forensic science curriculum. To frame this research, it was necessary to build up from the constructivist theories behind authentic learning to the specific proscribed lesson writing used. This chapter focuses on a review of the literature regarding learning theories; constructivist learning theory; specific applications of active learning; and the impact of authentic learning lessons on different genders, ethnicities, and students with varied foundational knowledge and self-concepts as science learners.

Historical Perspective and Theoretical Framework

Learning Theories

"Until recently, the accepted model for instruction was based on the hidden assumption that knowledge can be transferred intact from the mind of the teacher to the mind of the learner. Educators therefore focused on getting knowledge into the heads of the students, and educational researchers tried to find better ways of doing this" (Bodner, 1986, p. 873). The mind of the educator cannot directly transmit directly into the mind of the learner; the constructivist view describes the learner as someone who actively engages in the process of learning in order to incorporate and synthesize the information presented into a viable knowledge base. Creating an environment where authentic learning can take place followed a blending of three primary learning theories, those of Ausubel, Piaget, and Vygotsky.

Ausubel and Piaget created similar learning theories, describing learning as the creation of patterns in the mind and the understanding of new information as fitting into the pre-existing pattern. “For both theorists, new concepts that are well anchored by, or attached to existing schemata (or schemes) will be more readily learned and assimilated than new information relating to less established schemata” (Cakir, 2008, p. 194). Vygotsky’s theory followed the same idea of a required pre-existing pattern and included a specific zone of proximal development unique to each learner. The zones of proximal development have upper and lower limits for incorporating new information, dependent on cultural and historical factors unique to each learner. The major difference in the theories is the suggested teaching methodologies based on the preconstruction of knowledge and the incorporation of new information into established patterns (Cakir, 2008).

Ausubel favored a “top-down” or inductive approach, where student life experience solidified pre-existing notions or corrected misconceptions. Ausubel viewed direct didactic instruction as the best way to teach new concepts that form foundational knowledge. The modification of pre-existing patterns allows the learner to accept new concepts through reception learning, concepts explicitly taught by the educator. Piaget’s theory prefers a “bottom-up” or deductive strategy where each learner constructed his or her own knowledge through interaction with the surrounding environment. The learner used the experiential lessons to assimilate new knowledge and correct misconceptions on their own, but the ability to assimilate depended on age. Vygotsky emphasizes scaffolding, the creation of temporary constructs by an educator that were taken away as the learner internalized information through experienced activities. Examples of the methods needed to create such temporary constructs were nonspecific and designed based on the individual's zone of proximal development. "Despite these differences, however, the three learning theories depended to varying degrees on the existing cognitive frameworks that students brought to any learning environment" (Cakir, 2008, p. 196) and it is the pre-existing knowledge patterns that constructivism emphasized.

Constructivism as an instructional model included aspects of all three learning theories; Piaget focused largely on the importance of prior knowledge in particular, and using this prior knowledge to advance conceptual changes through exploration. Figure 1 depicts a learning cycle, based on Piagetian theory, developed by Atkin and Karplus in 1962 to demonstrate the interdependence on previously acquired knowledge, inquiry learning, and concept development (Arbor Scientific, 2002). A leading constructivist, Von Glaserfield, described knowledge as "actively built up from within by a thinking person; knowledge is not passively received through the senses or by any form of communication, and …social interactions between and among learners are central to the building of knowledge by individuals" (Cakir, 2008, p. 196).

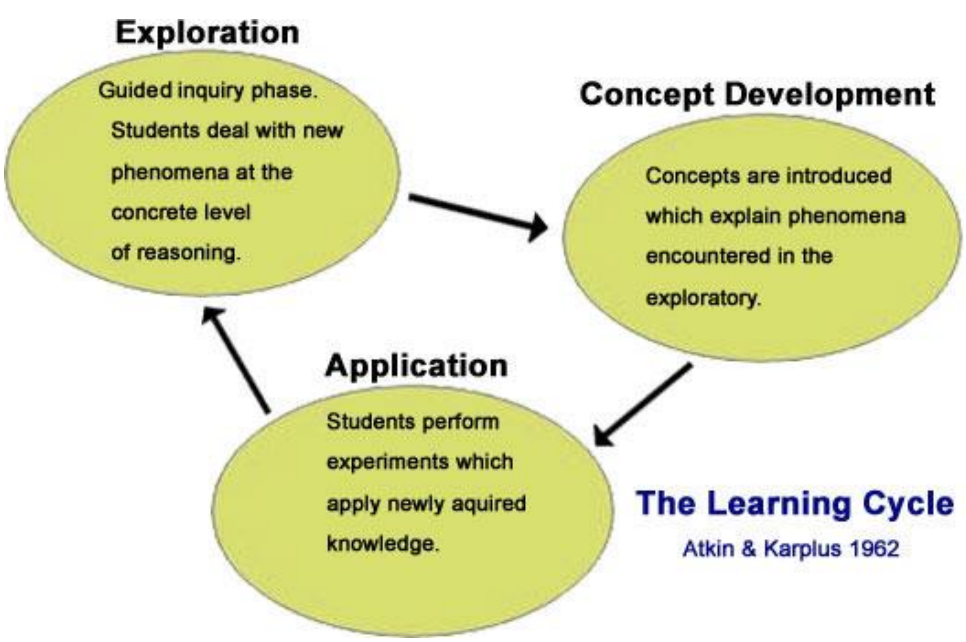


Figure 1: The Learning Cycle – Atkin and Karplus
(Arbor Scientific, 2002)

Constructivist pedagogy views learning as dependent on social interaction: interactions between teacher and students and amongst the students themselves. “Learning for understanding in classrooms required well designed hands on, as well as minds on, activities that challenged students’ existing conceptions leading students to reconstruct their personal theories. It was essential to create a classroom environment in which students were free to suggest tentative ideas and then to test them without concern for the rightness or wrongness of these ideas” (Cakir, 2008, p. 202). Beyond the created activities that challenge the pre-existing concepts within the learning cycle, educators developed an environment where authentic learning could take place.

“Authentic learning involved exploring the world around us, asking questions, identifying information resources, discovering connections, examining multiple perspectives, discussing ideas, and making informed decisions that have a real impact” (Callison, 2004, p. 34). Developing this environment maximized student engagement because they perceived the activity as relevant. Real world applications of learning and simulating life beyond the classroom encouraged an intrinsic desire to learn and apply the information taught. Authentic learning environments included classrooms being student centered, where the student acted as a scientific apprentice using multiple resources beyond the lecture provided by the instructor.

Authentic Learning Environments

The introduction and advocacy of active learning environments stemmed not only from the behavioral research developed pertaining to the learning patterns of students, but also from examining current student culture coupled with the fact that students had a very different expectation for the college classroom as well (Auster and Wylie, 2006). Students’ expectations of a quality education were rising, and college students demanded a classroom environment where they could not only obtain knowledge, but also learn how to apply that knowledge in the field.

The expectations revolved around professors developing and incorporating active, high impact learning experiences. They achieved the necessary requirements by focusing on multiple dimensions of the teaching process. Four of the most valuable dimensions included context setting, classroom preparation, classroom delivery, and continuous improvement. These were drawn as a Venn diagram (Figure 2, Auster and Wylie, 2006) demonstrating the intricacy and

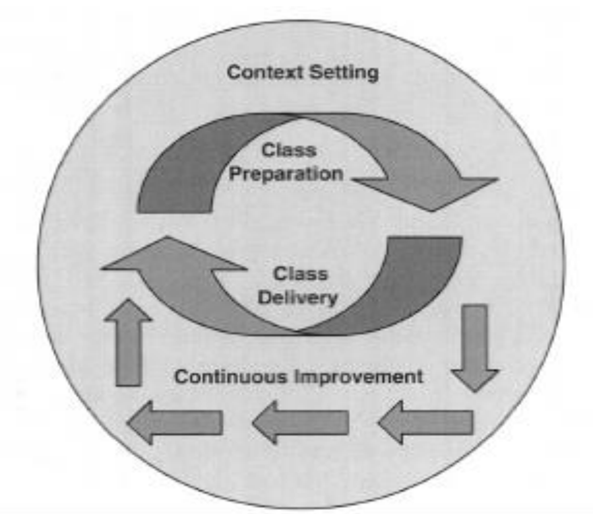


Figure 2: Multiple Dimensions of the Teaching Process
(Auster and Wylie, 2006)

interrelatedness of each with the other.

Although Auster and Wylie acknowledged the time commitments needed to make such changes in the college classroom, they noted that being able to draw on student input and experiences allowed the professor to reinforce key learning objectives the students would be taking away with them at the end of each lesson. The time commitment was not just a single block of time as the instructor consistently revisits classroom preparation and delivery to ensure continuous improvement. They confronted the argument that such active learning methodologies were applicable to small classrooms only. By acknowledging that certain lessons may be more conducive to a class size of 24-30, they encouraged educators not to dismiss the use of pair chat or verbal debriefing in a large lecture hall, both of which could easily bring active learning to the forefront. Auster and Wylie emphasized that even small changes could have an impact on a classroom environment and that planning was the key to managing the implementation of changes – planning and the commitment to making a change.

The combined first steps educators make towards incorporating active learning are often to explore the successful proscribed options available using the learning cycle desired, to create the proper environment, and to create the lessons needed for the change from passive to active learning. R. Hoffman and S. Y. McGuire (2010) went so far as to write out a 'cheat sheet' of valuable learning and teaching strategies that could be utilized by the professors who were new to active learning. The formula for success may have "initially been improvised, but these strategies were more than gimmicks, for they have proven themselves in practice and are based on recent advances in cognitive psychology that gives insight into why these approaches work" (Hoffman and McGuire, 2010, p. 378). The use of proscribed learning and teaching styles meant that the professors taught the core content they were responsible for and had the opportunity to educate the students on HOW to learn – "changing the rote memorizer who regurgitates information into independent, self-directed learners" (Hoffman and McGuire, 2010, p. 379).

Although Hoffman and McGuire referred to the teaching process as "magical and mystical", they recognized several methodologies that could be equally successful. They focused on four underlying psychological principles that they believed every good educator brought to the classroom: empathy, judicious interplay of groups and individuals, empowerment, and active learning. All students recognized an empathetic educator and responded by putting forth the extra effort needed to achieve a higher level of success. Judicious interplay of groups and individuals mimicked social skills that lasted a lifetime and allowed the students to come together in a peer setting where each of them was an equal protagonist to the learning taking place. Students felt empowered and began to feel capable of mastering the material placed before them, regardless of previous experiences or failures with the subject. Active learning was the component with the most flexibility for use, and the development of more lessons allowed the professor to easily incorporate the active learning process in the collegiate classroom (Hoffman and McGuire, 2010).

Examples of Constructivism

In a study done by Newmann and Wehlage at the University of Wisconsin-Madison three criteria were defined as the result of authentic learning: students could construct meaning and apply knowledge, students could use disciplined inquiry during construction of meaning, and students placed a value on outcome of learning beyond success in the classroom (Newmann & Wehlage, 1993).

“Authentic learning is created by developing a social situation where learning is an “active process of building knowledge and skills within a supportive group or community” (Herrington & Oliver, 2000, p. 42). Active learning techniques caused students to engage with the subject taught rather than passively taking in information, developing the described ‘active process of learning’. Examples of active learning activities included brainstorming, discussing, teaching, journaling, group work, focused listening, formulating questions, note taking, annotating, and role-playing. “Active Learning was the development of not only a student’s knowledge, but also their skills and abilities, by providing opportunities to talk and listen, read, write, and reflect…” (Meyers and Jones, 1993, p. 24). Michel described the foundation for active learning as three pronged, attributed to the shared methodologies found in Service or Problem-

Based learning, Participative Learning, and Cooperative Learning, respectively described below (lead researcher listed):

- Cooperative Learning: Working together in small groups, or through classroom discussion, allows the incorporation of five distinct elements: positive interdependence, face-to-face interaction, individual and group accountability, social skills, and group processing or feedback, all of which greatly enhance the learning process. (Johnson *et al*, 1991)
- Participative Learning: Engaging the student in the learning process by offering the opportunity to take part in selecting activities/assignments allows the student to assume a portion of the responsibility for development of the class and aided in the internalization of the importance of learning the material. (Mills Jones, 1999)
- Service or Problem-Based learning: Learning achieved through the resolution of a real world problem forces the student to learn the basic principles of the subject in order to discover/build the solution to the problem. This learning took place during the performance of a service for the local community. (Miller, 2004)

Cooperative learning involved students working together on a lab or field project and required teachers to structure cooperative interdependence among the students through including positive interdependence, individual accountability, face-to-face interaction, interpersonal and small group skills, and group processing. Positive interdependence was seen when the group acknowledged it would ‘sink or swim’ together. Students created their mutual goals, divided labor, materials, and roles; and acknowledged that assessment partially depended on the success of the group. Individual accountability ensured that individuals in the group were not ‘riding the coattails’ of the group and produced quality work in the group assigned tasks they were given.

The face-to-face interaction developed important cognitive abilities and interpersonal dynamics as students promoted each other’s work. The interactions included oral explanations of problem solving, discussions of the concepts learned, and Piagetian theory of connecting present knowledge to past learning. The interpersonal skills developed through cooperative learning connected subject matter to effective leadership, decision-making, trust-building, communication, and conflict management. After completion of the project, the instructor allowed necessary time for the groups to evaluate how well their group, and each individual, functioned while looking for ways to improve in the future.

Participative Learning followed all of the guidelines outlined for cooperative learning and increased empowerment to the student during curricular development. The students took an active role in determining the types of activities and assignments perceived to maximize their learning. Methods utilized to ensure participative learning included student involvement in syllabus and exam question writing, student determination of a grade scheme for the course, and others. Participative learning suggested that by including the student in the decision making process, the student would be more intrinsically motivated to complete the assignments. During participative learning, the educator became the moderator of discussion as well as the facilitator of knowledge.

Problem-based service courses presumed that students brought specific disciplinary knowledge to the problem, increasing the potential value of the service to the community in which the student lives. The problem-based service approach was advantageous because it provided highly structured learning opportunities to the students, often in a series of steps that moved the student toward a specific set of skills. Often, problem-based service courses were a direct link to local businesses and community groups, offering real world experience to the student while building a student's sense of accountability to the community.

Examples of Active Learning Implementation

During attempts to bring the learning and teaching styles outlined above to fruition, several designs for active learning lessons were developed, including Multi-Initiative Dissemination (MID), Peer Led Team Learning (PLTL), Peer Led Guided Inquiry (PLGI), and Process Oriented Guided Inquiry Learning (POGIL), each aiming to offer authentic learning opportunities to the student. Authentic learning, described as 'real-life' learning, uses lessons, activities, and lectures designed to challenge the student to build their own knowledge with minimum guidance from the educator. Authentic learning engages all of the senses of students, keeping them interested and actively thinking about the topic examined. Often authentic learning relies on real world examples, models, or tasks that include a variety of skills necessary for success in the course and in a career in the field in question. Since each example of active learning lessons mentioned above builds consecutively, brief descriptions of each help develop an understanding of the POGIL project.

The Multi Initiative Dissemination Project (MID) was funded by the National Science Foundation in 2000 to introduce and train professors at varied levels of tenure and experience in the use of active learning in the lecture hall (Burke *et al*., 2004). Berkley University set up four distinct active learning processes as workshops for the professors to peruse over a day and a half: Chem Connections, Molecular Science, New Traditions, and Peer Led Team Learning (http://www.cchem.berkeley.edu/midp/index.html?main.html&1). Each workshop described a proscriptive methodology professors could bring back to their universities and implement immediately. Chem Connections consisted of topical modules created specifically for the chemistry curricula taught within the first two years of college. Each module was two to four weeks long with relevant real world questions and lessons for teaching the chemistry required to answer them. Modules featured student centered activities and collaborative classroom activities, inquiry based laboratories, and media projects.

Modular Science was a computer assisted and web-based set of instructional materials, again for lower division chemistry courses. Two types of units, exploration units and Calibrated Peer Review™, created a logical progression between units, but an educator could use each as a stand-alone unit. The goal was to integrate telecommunications and technology into instructional processes so that students could explore data, visualize molecular models, collaborate, learn at their own pace to achieve mastery, and take responsibility for their own learning. New Traditions (NT) attempted to affect a deeper conceptual non-algorithmic understanding of chemistry. The focus was on constructing, implementing, and evaluating instructional paradigms that emphasized active student involvement. Participants would learn about several strategies they could mix and match to individual needs and teaching styles. These strategies included active learning strategies to supplement lecture (ConcepTests), guided inquiry and open ended laboratory experiments, cooperative learning activity group activities, information technology/computer tools (UW ChemPages, Mathcad, and WebCT), and new assessment techniques.

The Peer Led Team Learning (PLTL) model preserved the lecture and introduced a new structure into the schedule: a weekly two hour workshop where students interacted to solve carefully structured problems under the guidance of a team leader who was a peer, rather than the course instructor. The peer leader was a carefully selected student who had successfully completed the course, assigned to a group of six to eight students who worked as a team. The peer leader clarified goals, ensured the team members engaged with the materials and each other, built commitment and confidence within the team, and encouraged open discussion and debate about concepts taught during the lectures.

The MID workshop environment was unique and invited faculty to rethink solutions to the traditional problems found in teaching introductory chemistry at the collegiate level. The workshop collected and quantified information pertaining to opinions of the professors before the workshop concerning the most efficient types of collegiate learning. Statistically, 78% of instructors exclusively used lecture to present new material, although they felt lecturing was only 33% effective. Attending professors ranked in-class problem solving as the most effective (40%) method yet only 67% of attending professors used this approach regularly. Guided inquiry was in use, but the 29% of professors using it perceived that the methodology was only 13% effective (Burke *et al*, 2004).

Compilations of both student and instructor goals that should be incorporated during classroom preparation collected during the MID workshops revealed specific student expectations. Professors expected student engagement at an intellectual level that would allow attainment of a working knowledge of the material and a better understanding of the fundamental principles of the science. This better understanding would lead the student to become a better problem solver and critical thinker, and to perform analyses at algorithmic and conceptual levels (Burke *et al*, 2004). Within these expectations, an educator must be prepared to incorporate lessons that allow active engagement through hands-on experiences in the classroom as well as in the laboratory. In an attempt to facilitate the use of one of the four active learning styles into the university setting, educators also made a list of the most anticipated challenges the educator considering implementation needed to overcome.

> “Challenges include student acceptance, administrators’ perspective, appraisal by teaching peers or colleagues, grade inflation issues, et cetera. The advantage of this portion of the workshop is that attendees are able to interact with principle investigators or presenters who have encountered implementation issues, worked through them, and effectively integrated the active-learning strategies into an existing curriculum” (Burke *et al*, 2004, p. 900).

The Peer Led Team Learning taught at the MID Workshop incorporated cooperative learning activities into the course, but not during the time allotted for the lecture. Necessary considerations before incorporating PLTL into the classroom consisted of six critical components:

1. The university/organization promotes learning, taking into consideration the limits on group size, space, time, noise level, and teaching resources.
2. The materials encourage active learning, work well in groups, and are appropriately challenging and integrated with the course.
3. The peer leaders are well trained and closely supervised
4. The instructor is involved with the workshops that train peer leaders and with the peer leaders themselves.
5. The PLTL workshops are an integral part of the course, coordinated with the lecture, laboratory, and exams.
6. The university/organization using the program supports its use.

(Cracolice and Deming, 2001, p. 21)

Assigning a peer leader to the cooperative learning team, instructors placed more responsibility for learning onto the students. Use of the peer leader enhanced the activation of the students' learning cycle, with the opportunity for additional guidance from the educator if needed. "The PLTL model organizes students from various grade levels into workshop groups or teams that meet regularly to solve problems and reinforce science content without teacher intervention…[with the groups] demonstrating leadership potential and strong interpersonal skills" (Cracolice and Deming, 2001, p. 20). When utilized at a small Eastern research university in the United States, the PLTL model was slightly modified to preserve lecture time for the instructor and brought the PLTL methodology to only recitation sections, led by graduate students. The incorporation of the group learning activity proved impractical for lecture use, potentially due to class size, but the professors still wanted to incorporate active learning into the course (Tien, 2002).

Peer Led Guided Inquiry is a scheme that evolved from PLTL, incorporating the use of small groups *within* the large lecture arena and emphasizing cooperative learning inquiry scaled up for large enrollment classes. This methodology was typically for the lecture style course that had an accompanying laboratory section designed to enhance the schedule of content delivery. In one instance, a PLGI session simply supplanted just one of the weekly lectures, keeping the amount of instructional time the same as a traditional section. During a PLGI session, students worked in groups of four on guided inquiry activities that were designed specifically for the course to approximate Atkin and Karplus' learning cycle. This learning cycle approach used a laboratory experiment to expose students to the concept developed, engaging the students in an exploration, or data-gathering phase. The students and/or teacher derived the concept from the data, usually during a classroom discussion, and then students had the opportunity to explore the usefulness of the concept as they attempted to apply or further develop the concept (Lewis & Lewis, 2005).

New activities introduced before lecture limited evaluation of student performance during group work and the PLGI transferred from in-class to assigned homework. In the recognized example of use, a brief weekly quiz assessed the content addressed during the previous week's PLGI session. To ensure the promotion of the usage of PLGI, weekly training sessions for peer leaders were required in an attempt to build a more equitable learning experience for every student in the group. To ensure that the individual peer leaders were performing their skill sets adequately, observations were performed at least twice per semester and feedback was provided by the professor (Lewis & Lewis, 2008).

Implementation of the POGIL Project

Process Oriented Guided Inquiry Lessons were simply a more definitive example of PLGI activities. The implementation of Process Oriented Guided Inquiry Learning (POGILs) in the collegiate classroom meant taking PLTL processes and PLGI methods one-step farther by developing a sequence of activities completed by a small group of students during the lecture itself. This eliminated the focus of active learning in a non-lecture format (recitation sections), and was utilized during every lecture, instead of just once a week. The Guided Inquiry process "was an innovative approach to learning that shifts the focus in the classroom from the teacher to the student through the use of specially designed activity sheets that follow Lawson, Abraham, and Renner's (1989) learning cycle and Johnson, Johnson, and Smith's (1991) collaborative group theory" (Bunce *et al*, 2010). The diagram, given in Figure 3, depicts the evolved learning cycle desired during the use of the POGIL exercise.

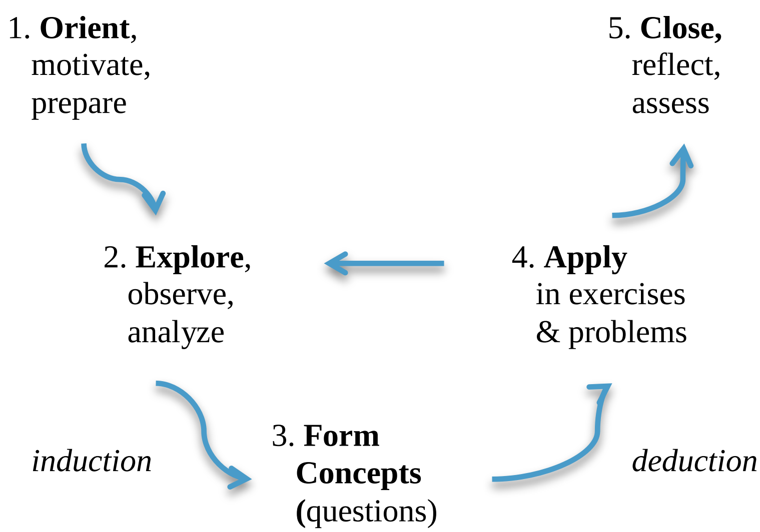


Figure 3: The POGIL Learning Cycle
(Kussmaul & Wenzel, 2012, p. 8)

The POGIL activity presented a model to the group of students: a diagram, a set of data, a video, an applet, or simply bits of information that would be crucial to the development of an idea. The model generated ideas, anything from experience with an equation, a data table that demonstrates a particular theme, to a decipherable portion of text with the desired skill set (Bunce, 2010). The flexibility of the models used in the activities allows the creation of unique and course specific activities, making this active learning methodology the most attractive choice for potential adaptation for forensics science for our work.

Critical thinking questions follow the 'model' that the group works on collaboratively. The guided questions advance the knowledge base of the group by revealing desired relationships, eliciting a particular interpretation, or leading the students to make a set of inferences and conclusions that are necessary for forward momentum in understanding the content. Not all questions are critical-thinking questions; grouped among the models are exercises and problems designed to add additional practice and even mirroring required homework questions so the students experience relevant course material (Bunce, 2010).

> "The activity sheets themselves can be focused on *concept formation*, where the students are presented with a concept and are guided through the process of understanding it, or *concept invention,* where the students formulate the concept on the basis of what they have learned from the data presented. POGIL emphasizes not only achievement but also the development of process skills such as critical thinking, problem solving, information processing, and metacognition. In addition there are two process skills developed through the small-group interaction, namely, teamwork and communication." (Bunce *et al*, 2010)

The POGIL project started in a small general chemistry classroom generating journal articles detailing the active learning process that they created. Conferences held several times a year allowed educators to train in the use and creation of new POGIL lessons. The following paragraphs are a synopsis of the combined efforts of John J. Farrell, Richard S. Moog, and James N. Spencer describing the suggested implementation of POGILs in the classroom (Farrell *et al*, 1999).

The environment created during the use of POGILs maximized time for small group work and teacher intervention when and if needed. Small groups were established at the beginning of the course, predominantly groups of four, with each member assigned a specific role to play for that class session – "Every day, each member of the group is assigned new roles. When the students each have a specific role, then each is responsible for a particular aspect of the group's work making it less likely that an individual will become disengaged" (Farrell *et al*, 1999, 570). Each role reflected a different responsibility for the member, focusing on a particular aspect of the group's work (in addition to completing the activity). Examples of the four main roles utilized by groups include the manager, the recorder, the technician, and the reflector/presenter.

The manager was clearly in charge, attempting to make sure that the assigned task was completed and that the other members of the group fulfilled their assigned roles. When questions arose within the group, the manager was responsible for getting the instructor's attention and identifying the information needed by the group to complete the activity. The recorder was responsible for the written portion of the activity, noting the answers, observations, insights, and other verbal byplay that the group had during the activity. The physical copy of the activity became a single grade shared by the entire group. Many activities in the science classroom required the use of a calculator or some technical device, and the technician performed all jobs requiring technical skills for that day. To enhance the larger lecture hall learning experience, the smaller groups presented their answers to specific questions during a debriefing segment at the end of class. The only student speaking for the entire group at that time was the reflector/presenter. Instructors could ask the presenter to give an opinion on how the group performed that day and suggest necessary changes (Bunce, 2010).

"The membership of the groups changes, frequently at first, less frequently as the semester progresses…in the absence of substantive information about relative student performance, group members are selected randomly, or in a manner that enables every student to meet and work with every other" (Farrell *et al*, 1999, p. 571). Implementing changes due to necessity and/or timing was one of the primary roles of the instructor overseeing the POGIL process. The instructor typically maintained a distance, or hands-off approach, allowing most of the learning to come from within the groups themselves, while the instructor mingled among the various groups, observing and listening, examining the recorder's answers, and intervening only when necessary. Lecturing was not considered the primary task of the instructor although it was used in an introductory capacity, as a warm up activity demonstrating a particular skill, or through the guise of a demonstration, all of which could then be utilized as a model for the upcoming POGIL (Bunce, 2010).

Summarized, detailed descriptions of the roles of the instructor provided on the POGIL website, https://pogil.org, follow. Four primary roles existed for the instructor in a productive application of the POGIL project. The teacher as leader guided the small groups towards deeper applications of the data, answering questions by engaging only four to five students at a time then bringing the large group back together to allow the reporting process to proceed. The teacher as monitor of time ensured the lesson moved forward at an adequate and effective pace, allowing for the possibility of adjustments to enhance understanding. The educator used this allotted time for monitoring to highlight and correct naive views, bringing these views to the larger group for discussion.

The teacher as facilitator of information moved among the students, addressing confusion about the activity with each group individually without directly giving the answers to the critical thinking questions. This minimized interference with the building of the thought process makes POGILs an active learning lesson. Lastly, the teacher as evaluator assesses the progress of the students, but not through the assignment of grades. The evaluation of the effectiveness of the lesson took place as the reporter from each group answered the guided questions, exercises, and problems. During evaluation, the educator could make a decision as to the effectiveness of the lesson, determining if alterations were needed in future lessons or if the class was prepared to go on to the next section. “There is a strong temptation to intervene, but this should be avoided if possible. Our experience is that students learn best and retain information longer if they (the group working together) discover the answer; telling the students the correct answer has little benefit” (Farrell *et al*, 1999, p. 571).

The role that takes place behind the scenes is the educator preparing the detailed curriculum and writing the syllabus. The educator considers a possible timeline for the course, allowing for the administration of examinations, grading all achievement activities, and preparing the POGIL activities. An educator can seek available POGIL activities that have been successfully utilized in other classrooms, as reported by the POGIL project, or create their own POGILs, following the training and basic outline for a POGIL activity. The laboratory sections associated with the lectures should follow the same guiding principles as the classroom meetings. Students perform the laboratory activities designed to enhance the coursework in pairs or small groups, and consolidate the data obtained from all for discussion. These lab sessions use guided inquiry or discovery experiments to lead students to hypothesis formation and testing. Guiding questions are desirable along the way to require a student to think about various steps of the investigation and not simply follow instructions (Farrell *et al*, 1999).

Difficulties advancing the use of POGIL

The changes made using the newest approaches to education and their incorporation into the university setting are typically very slow. During his acceptance address for the 2005 George C. Pimentel Award, J. N. Spencer proposed three great truths that helped explain the lack of evident change at the collegiate level. During the explanation of each “truths”, he attempted to discredit such ideologies slowing the rate of growth of active learning attempted by his peers:

Great Truth 1 – Teachers seldom accept responsibility for themselves. When confronted with the questions about WHY a professor continues to use didactic lectures, a passive learning style, an oft-cited reason is that it was good enough for them, why should it not continue to be good enough for the future generations of students.

Great Truth 2 – Teachers rationalize away evidence that contradicts their beliefs. Study upon study has shown major findings in the student learning process, and yet professors continue to hold the opinion that traditional styles are best. Such rationalizations involve the manipulation of data, allowing them to claim that opinion, not data, created the proposed changes to teaching methodology.

Great Truth 3 - Telling is not teaching. I cannot transfer an idea intact from my head to the head of a learner. Even eye-catching demonstrations may not be adequate to engage the student learning necessary to internalize data. The development of the POGIL allows the application of the following tenets:

- Previous knowledge dramatically influences what goes on in the learner's head.
- The instructor needs to know what the students already know and what is going on in their minds.
- Students construct their own knowledge.

(Spencer, 2006, p. 529-531)

The examination of recent applications of the proscribed teaching methodology, independent of psychological research on learning styles, offered evidence towards its effectiveness in the collegiate classroom. Primary focus remains in biology, physics, and chemistry 100 level courses, but additional studies quantitatively supported the use of POGIL activities in diverse curricula.

Published Quantitative Studies between 1999 and 2009

- 1999 - Farrell, Moog, and Spencer, Chemistry: the study showed an increase in attained averages in introductory chemistry, students achieving A grades increased from 19.3% to 24.2%, B grades increased from 33.1% to 40.6%, and C grades remained the same (Farrell, Moog, and Spencer, 1999).
- 2006 - A liberal arts college, Chemistry: the study showed a 3.3% higher average on the exam than any other year, while another shows a better distribution of grades with 3% fewer A's, 13% more B's, 15% more C's, 14% more D's, 4% less F's and 25% fewer withdrawals (Eberlein *et al*, 2008).

Published Quantitative Studies between 2010 - 2014

- 2010 – A College of Pharmacy in Tennessee, Medicinal Chemistry: the study compared exam scores, control group (n=66), experimental group (n=76), where student scores went from 82.3% to 85.0% ($p=0.010$) (Brown, S., 2010).
- 2010 – A small private college, Anatomy and Physiology: the study compared exam, control group (n=25), experimental group Year 1 (n=18), experimental group Year 2 (n=31) and experimental group (n=17) where students' scores went from 76.0% to 77.8% ($p < 0.05$), 86.9 ($p < 0.05$), and 89.3 ($p < 0.05$) respectively (Brown, P., 2010).
- 2011 – Application to Foreign Language: control (n=16), experimental (n=14), where student scores went from 84% to 92% (no p value given). (Johnson, 2011)

- 2011 – Illinois State University, Upper Division Environmental Science: control (n=15-30), experimental (n=15-30), the study used a quiz and an exam score where student scores increased from 68.3 to 70.7 (p=0.86) and 74.0 to 75.6 (p=0.59) respectively (Jin & Bierma, 2011).
- 2011 – University of North Dakota, Aviation: control group (11), experimental group (n=11), the study used four exams throughout a semester; none of the exams showed an improvement in scores but students felt more confident with knowledge learned and ability to apply aviation knowledge in the lab (Vacek, 2011).
- 2012 – University of Nebraska, Biochemistry: control (n≤180), experimental (n≤180) the study evaluated questions totaling 21 points throughout module where student scores went from 9.1/21 to 12.5/21 (no p value listed) (Bailey & Minderhout, 2012).
- 2013 – Medium sized Midwestern State University, Chemistry: control (n=19), experimental (n=21); student scores went from 88.4 to 86.3 (p=0.51) the study demonstrated a blended classroom does not negatively affect retention (Baum, 2013).
- 2013 – An Australian University, Physiology: the study used three variations from lecture (n=354), control group, traditional POGIL group, POGIL without reporting group, and an untrained Facilitator group. Initial assessment showed significant increased differences in non-reporting (p=0.002) and new facilitator groups (p=0.0005) only, but a surprise assessment after an additional two weeks showed the decreased retention in all groups with the POGIL group decreasing in scores with the least significance (p=0.03) (Vanags *et al*., 2013).
- 2014 – Capital University, Columbus Ohio, Biochemistry: control (n=26), experimental (n=13), a comparison of pre-test to post-test where control group scores went from 26.3

to 76.1 and experimental scores went from 18.3 to 74.2, demonstrating a larger increase in group using the POGIL activities to read through primary literature (no p value listed) (Murray, 2014).

The results above listed demonstrate a growing trend in the use of POGIL activities to increase academic achievement and retention but did not incorporate forensic science in its diversity.

Inclusion of Forensic Science

None of the published research to date has revealed an attempt to bring the active learning cycle into the forensic science courses garnering such interest due to media sources (e.g. *NCIS*, *CSI*, and *Forensic Files*). "In recent years, the demand for forensic scientists has increased for many reasons, including population demographics, increased awareness of forensic science by law enforcement, jury expectations, and increased public awareness for forensic science through the popular media" (National Institute of Justice, 2008). This media attention has resulted in the explosive demand by college students for academic courses that will better prepare them for a career in forensic science. In recent years, many colleges and universities responded to this explosion of interest by creating varied new academic programs, from undergraduate to doctoral forensic science degrees. The curricula seen in these programs range from rigorous scientific coursework to little more than criminal justice degrees with required internships.

As attention towards forensic science increases, an understanding of the impact forensic science has on a community is important. Forensic scientists must understand the principles, practices, and context of science, including the application of the scientific method. Apprenticeship training originally transmitted desired skill sets yet did not adequately relay foundation science skill sets. A forensic scientist needs to recognize what to measure; consider associated statistics, biases, and errors to avoid; understand threats to the validity of the evidence, probability calculations, and how to document and report on scientific analyses.

> "Among many skills, forensic science education and training must provide the tools needed to understand probabilities and the limits of decision making under conditions of uncertainty. To correct some of these existing deficiencies, the starting place must be better undergraduate and graduate programs, as well as increased opportunities for continuing education."
>
> *(Strengthening Forensic Science in the United States: A Path Forward,* 2009*)*

As interest in forensic science grew, so did the number of colleges and universities creating new courses and certificate and degree programs designed to prepare students for careers in forensic science. Introductory forensic science courses prepare students for advanced scientific techniques and applications, but the introductory course serves another function as well. Forensic science courses designed to count for a physical science elective course with laboratory in most liberal arts requirements, as taught at a northeastern research university, are survey courses due to the broad spectrum of content covered. Topics in the survey course cover how forensic science focuses on the application of scientific methods in a wide variety of physical and life sciences as well as techniques applied to legal questions. The curriculum included advances in scientific methods and principles that had an enormous impact upon law enforcement and the entire criminal justice system made popular by the Hollywood versions of these applications.

Scientific methods specifically relevant to crime detection and analysis explored biology, chemistry, and physics applications, instruction beyond a student's high school experience but with no prerequisite science courses. The evaluation of biological, chemical, and physical evidence emphasized *understanding* the science behind the techniques used. Topics included blood analysis, organic and inorganic evidence analysis, microscopic investigations, hair analysis, DNA analysis, drug chemistry and toxicology, fiber comparisons, paints, glass compositions and fragmentation, fingerprints, soil comparisons, and arson investigations – all of which made excellent model creations to incorporate the active learning method of POGIL.

About two-thirds of the students enrolled in the course chosen for this study were non-science majors required to complete a life science or physical science course with a laboratory experience. The most commonly chosen elective foundational courses to complete this requirement were chemistry, biology, physics, and earth science, with chemistry and biology the most often chosen. With the popularity of forensic science, it became an attractive alternative to other course offerings – specifically appealing to students that self-identified as 'not good at science'. We hypothesized that the alternative active learning methodologies explored within the chemistry curricula could easily segue into the forensic science classroom, even the large lecture classroom as was typically seen at the research university where this investigation took place.

Student Characteristics

This study also incorporated the diversity of the student body taking a typical forensic science survey course. The use of active learning required small group dynamics and the consideration of how diverse students would interact in the group during the completion of the assignment. To develop groups that would be homogenous demanded that instructors look at student characteristics, such as student performance and gender" (Farrell *et al*., 1999).

Farrell *et al*. listed gender as a consideration for grouping students. "Young female students don't like math and science as much as male students of the same age, don't see the subjects as relevant to their futures, and don't feel confident in their own abilities to succeed in the subjects" (Alexakos & Antoine, 2003, p. 31). Early research indicated that female students taking science classes at the collegiate level excel with passive learning methodologies due to the female's ability to focus on objectives during a lecture and stay focused until the end goal of understanding the new material is accomplished (Jacobs, 1996). As active learning has risen in use, other current research supported the theory that females perform better when implementing active learning methodologies. The probable reasons listed as causes for the gender differences is that females identified the objectives of a lesson and placed import on the lessons, enabling them to facilitate their own learning. Although neither sex claimed difficulty in engaging and contributing in a small group, males were less likely to trust information provided by peers as being valuable and applicable. Males were also more likely to focus on information identified as needed for an exam, ignoring a larger picture of understanding, causing them to perform poorer on exams (Wyller, 2002).

"Undergraduate students often appear to be treated as interchangeable entities without acknowledgement of the central role of the individual students, their learning histories, and their personal characteristic…through constructivist activities teachers can structure classrooms with the intention of maximizing student learning by making the learning the work of the student" (Tanner, 2013, p. 322). Ethnicity may play a vital role in the learning history that student brings to the small group. There were race-ethnic disparities at all education levels in the rate at which groups participated in science and engineering. (National Academy of Science, 2011) Those disparities could be seen within a learning environment as creating inequalities between what one ethnic group is willing to offer a collaborative group compared with another based on learning histories.

Ethnically grouping a heterogeneous cooperative learning group allowed multiple learning and communication styles to come together, allowing different ethnicities to learn about the communication necessary within a successful group. When bringing together several ethnicities, a large learning curve existed regarding effective communication, but the heterogeneous grouping could maximize different learning styles and raise the entire classes' scores, not just one particular ethnic group. "Students who have typically underperformed in science, such as African Americans, may benefit the most from types of innovative pedagogies which promote interpersonal interaction, collaborative learning, as well as the sharing of information" (Freeman *et al*, 2008, p. 227-228)

A third student characteristic considered was whether the student declared a STEM major before taking the class.

> "It can be argued that motivation is the central psychological experience of students as they experience classroom work through persistence, effort, and choice. Motivation is concerned with students' beliefs about their competence, the quality of task engagement, as well as goals or reasons for learning, and the direction, intensity and direction of academic behaviors…the role of motivation in STEM learning and performance is paramount." (Freeman *et al*. 2008, p. 228)

Students choosing a major in a STEM field may have more confidence in their ability to learn math and science and demonstrate specific characteristics that aid them in being successful. "Science literacy development may occur differently in Stem and non-STEM majors and may require different educational approaches" (Jin & Bierma, 2013, 25). Students with STEM majors may perceive themselves as being better able to become science literate and could possibly influence the learning in a small group collaboration. A student more confident in his/her ability to assume a leadership role regularly allows other students in the group to ‘ride coattails’ rather than learn the material themselves, creating a gap between achievement scores.

The final characteristic, college entrance exam scores, as indicators of foundational knowledge, determined the student’s predicted performance, referred to by Farrell *et al* as being fundamentally important, as was gender. “It is recognized that gaining scientific knowledge is especially difficult for students…Math SAT scores are traditionally used to identify students with an aptitude in science and math related courses” (Bunce, 1993, p. 183). Foundational knowledge included both Math and English scores as the group work relied upon reading comprehension and ability for clear communication. “In a sample of 228 national and regional colleges and universities, the average SAT score was by far the most significant factor explaining retention. Specifically, the results suggest that a 100-point increase in the average SAT would lead to an increase of about 10% in a national or regional institution’s six-year graduation rate. Similarly, a 100 point increase in the freshman to sophomore retention rate of roughly 5%” (Doti, 2004, p. B18).

Conceptual Model

In order to understand the impact that a hybrid lecture/active learning environment has on student achievement, it was important to consider multiple proscribed methodologies that allowed for an informed decision about which lesson style made the most of the educators teaching style. Learning theories developed into constructivist pedagogy, interaction between experiences and ideas generated knowledge and meaning. Authentic learning, real life learning, was encouraged in constructivism and educators should develop an environment where students create their own learning.

Our study reported here contributes to the research base by following the proscription of POGIL activities during the writing of active lessons, but similarities to other described methods may appear. “Much of the confusion associated with labels for different pedagogies is that the individual instructors adopt and adapt instructional ideas that suit them and their situation (Eberlein, 2008, p. 271). This study included a northeastern R1 university not currently using active learning in the classroom, and the course chosen for the study had no previously created lessons to incorporate, requiring the writing of the lessons used. The implementation of the intervention used a hybrid model of lecture and POGIL activities, although incorporating aspects of PLTL and PLGI. “The archetypical models of PBL, POGIL, or PLTL often become blended with each other and other pedagogies to the point that one short acronym is insufficient to capture what goes on in the classroom….Some instructors deliberately hybridize different pedagogies with the intent of optimizing the beneficial elements of each” (Eberlein, 2008, p. 271).

The environment should have both an educator who facilitates learning as a guide or manager and activities that allow students to collaborate using guided active learning lessons to assimilate new information. A blending of cooperative learning methodologies- PLTL, PLGI, and POGIL – with the use of the POGIL project activities as a template was the foundation for the forensic science course created activities. These activities were interspersed among lectures to create a hybrid active learning methodology hypothesized to raise student averages. This causal/comparative study analyzed the effect of the hybrid method intervention on exam scores. We evaluated four student characteristics that may have also affected the outcomes due to variations in the integration of the intervention. Through the data analysis, we examined the potential relationships existing between the intervention and each of the student characteristics, and between the student characteristics as they affected student averages.

Summary of Chapter Two

This chapter reviewed literature describing the development of active learning pedagogy and its previous and current applications in college classrooms. It began with historical perspectives, and then reviewed the emergence of active learning, the applications of active learning that led to the POGIL learning cycle, and the current uses of POGIL activities at the collegiate level. The literature review then segued into the desire for active learning in forensic science classrooms, as well as the student characteristics that potentially affect the implications of active learning on exam scores. The premise underscoring the conceptual framework of this study is that active learning applications in a large lecture environment have the potential to increase the student averages for the course. It also envisions the potential for identifying student characteristics that may be more conducive to the active learning pedagogy.

CHAPTER THREE: Methodology

This chapter describes in detail the research design and methods used in this study. The purpose of this study was to examine the effect of the incorporation of a hybrid teaching methodology that blended traditional lectures with Process Oriented Guided Inquiry Lessons (POGILs) on the overall academic achievement of a diverse student body in a large lecture setting. Student characteristics that were taken into consideration included gender, ethnicity, declared major (STEM or non-STEM) and SAT scores. The chapter begins with an overview of the research design and study questions. Next is a description of the source of data for the study, the population the study used, and the design and implementation of the intervention and the instrumentation. Lastly, this chapter addresses the statistical analyses performed.

Research Design

This study analyzed the effect of created course-specific active learning lessons on examination scores earned over the semester, where the cause was the intervention of the hybrid lecture/POGIL methodology. As a causal experiential design, an established population did not receive the intervention (years 2007-2010) and a population did receive the intervention (years 2011-2014). The initial stage of this study analyzed a dichotomous event, whether the intervention worked or not, and given the limited range of the variable (0=pre-intervention; 1=post-intervention) t-tests were used subsequent to linear regressions to model event occurrence. As is typical with most experiential research designs, the researcher assumed a significance level of $\alpha \leq 0.05$.

“The inclusion of all salient interaction effects is extremely important in analyses designed to recognize and promote a causal effect. Interactions are used to qualify causation: they contain information on how specific background conditions or characteristics - and the treatment or program under study - might work together to modify the probability of occurrence of a targeted event" (O'Connell & Gray, 2011, p. 253). The interaction effects considered in this study included all two way, three way, and four way interactions between the intervention, gender, ethnicity, declared major, and SAT scores. Sequential ANOVA regression analyses examined the separate and combined influence of these factors on the intervention as an aid in learning/retention.

Methods

Rationale for a Causal Comparative/Quasi Experiential Design

"Attempts to understand what works in educational and psychological research, possibly all research that seeks to identify ways to improve the human condition, continue to be debated through scientifically based research, causality research, and published evidence-based practices" (Riehl 2006; Schneider *et al*., 2007; Towne *et al*., 2004). A key characteristic of causal-comparative research is that participants may or may not be randomly assigned to groups before the study. This is due to the involvement of an event or situation that has already occurred with a group(s) already formed. The groups selected, defined by Gay *et al*. (2006) as *comparison groups*, are selected because one group was not exposed to an experience whereas the second group was. The experience becomes the independent variable studied.

A causal-comparative study design attempts to determine cause and effect. Researchers often decide to study particular variables with causal-comparative methodologies because a variable is involved in the study that cannot be manipulated for ethical and/or practical reasons. This approach is, therefore, a common design in educational research studies. When designing a causal-comparative study there must be at least one independent variable and two or more groups. The independent variable must be clearly and operationally defined (the intervention in this study) and any other independent variables considered should be non-manipulative. Non-manipulative independent variables in this study include gender, ethnicity, identified declared majors as STEM or non-STEM, and SAT scores, defined as possible student characteristics that may be covariates, or confounders.

"Randomization to treatment is an important component in the experimental design of treatment or intervention studies, but, at times, researchers who are interested in the causes of an event may be unable to assign participants to a condition. In such instances, quasi- or non-experimental research designs can yield strong causal inferences when methods to approximate the randomization process and adjust for selection bias are incorporated into the design." (O'Connell & Gray, 2011, p. 249) Since the course used for this study had only a single section each year, it was necessary to perform a quasi-experimental study of the course over multiple years.

"In quasi-experiments, the investigator uses control and experimental groups but does not randomly assign participants to groups." (Cresswell, 2003, p. 167) The populations were split into two groups, pre- and post-intervention, based upon the chronological years that they completed the course. The opportunity to study a larger population, allowing more in-depth comparisons among populations, was of particular interest in this study to determine if certain student descriptors could be isolated as being more inclined to affect the use of active learning. The inclusion of eight years, four pre-intervention and four post-intervention, identified this as a longitudinal study.

The Institutional Review Board (IRB), IRB#14-103, granted permission to use data from human subjects for the study populations. We then matched the collection of student provided data through the Office of Institutional Research and Assessment (OIRA) to student earned test scores using student identification numbers before coding the data. After the completion of coding, destruction of all student identifiers provided anonymity to all participants.

Population

The subjects of this study were undergraduate students enrolled in the survey course Forensic Science (CHE 113) during the spring semesters of 2007 - 2014. The majority of students enrolled in CHE113 were juniors and seniors looking to complete the physical science with laboratory requirement needed for the non-science majors offered at the university. There is no required chemistry, biology, or earth science prerequisite requirement for this survey course, although a background in the sciences equivalent to a high school science education was expected. Additionally, about one-fourth of the class were required to take this course to complete their forensic science Integrated Learning Major (IML); most of these students were science majors.

The number of students completing this course ranged between 200 and 225 students for each semester studied. Since cumulative student averages were used to measure outcomes, students missing exam scores were eliminated (n=39). The exam missing for eliminated students was primarily the first exam; OIRA did not provide data for students dropping the class. The data collected from the population included their gender, ethnicity, the major declared by the student at the time they took the course, and their SAT score. The lack of recorded SAT scores also eliminated students (n=362), such that the population data did not equal the entire course enrolled population. The four semesters pre-intervention had a cumulative total of 749 students whereas the four semester post-intervention population contained 687 students.

In order to quantify the equivalency of the pre- and post-intervention populations, we retrieved and analyzed SAT scores, developed a boxplot of the SAT scores of each population, shown in Figure 4, and then separated the data by year in study in Figure 5. The SAT scores for pre-intervention were slightly higher (1178 ±139) than post intervention (1141 ±138) and a homogeneity of variances for SAT scores for pre-intervention and post-intervention was established, as assessed by Levene's test for equality of variance ($p = 0.773$). Analysis of the SAT scores provided evidence for homogeneity of variance using an independent t-test after a box plot analysis identified any outliers in the data. The box plot identified two outliers, one from pre-intervention and one from post-intervention, which the researchers eliminated from the study. A Shapiro-Wilkes test ($p > 0.05$) assessed that the SAT scores were normally distributed. Histograms of the SAT score variances, displayed in Figures 6 and 7, demonstrate normal distribution. The SAT scores represented one of two continuous data samples and although analyzed as a continuous variable, researchers condensed data to increments of 100 for ease of data display only.

The four exam scores earned during the enrolled year were matched to student identification numbers and student descriptors. Once matched, all identification numbers were deleted from the data set and descriptive statistics were analyzed to examine the relationship between exam averages and the variables gender, ethnicity, declared major, and SAT scores. These descriptive statistics can be found in Table 1. The descriptive statistics, broken down by year of study to offer detailed information, can be found in Table 2, with corresponding histograms provided in Appendix D.

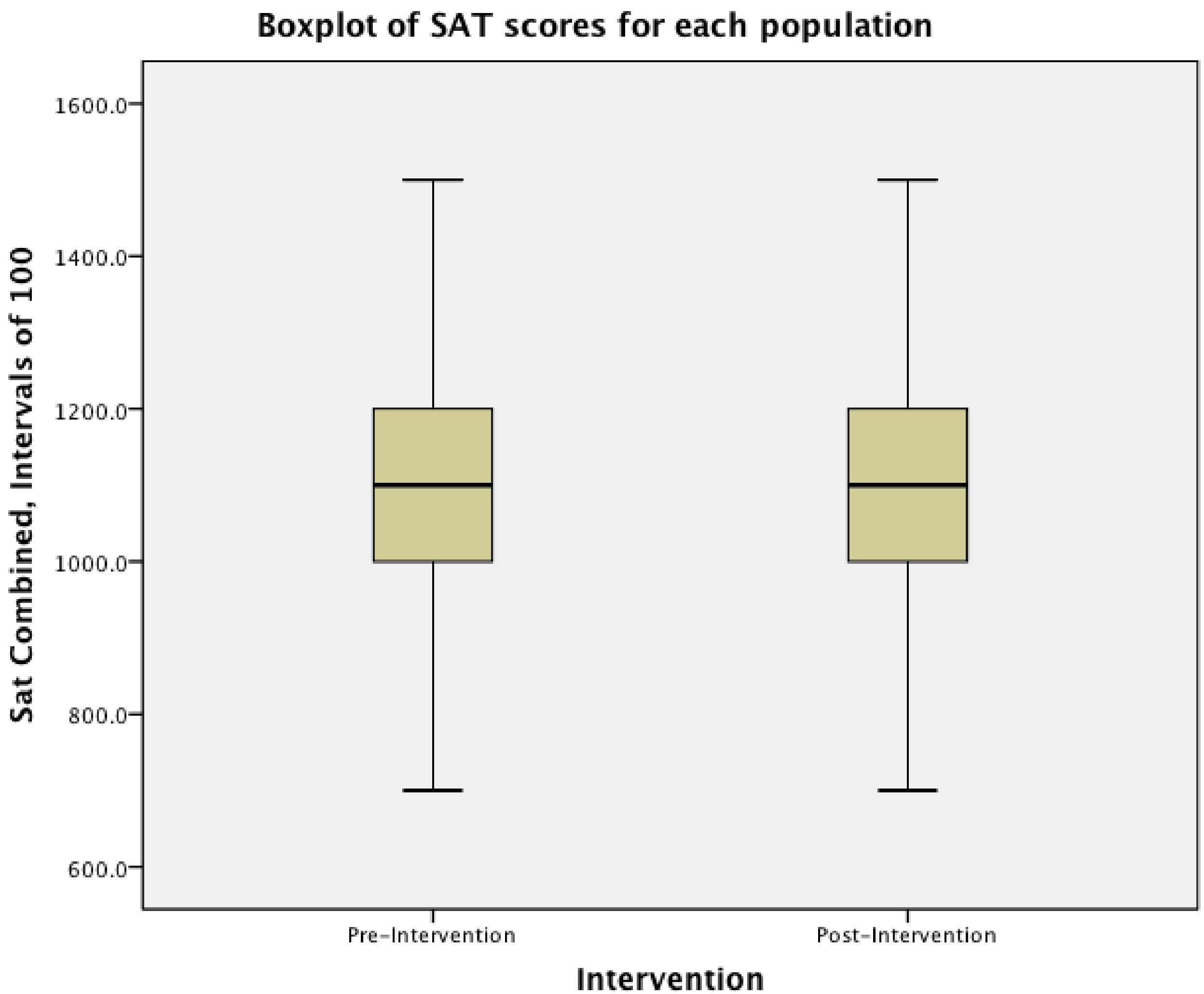


Figure 4: Boxplot of SAT scores for populations

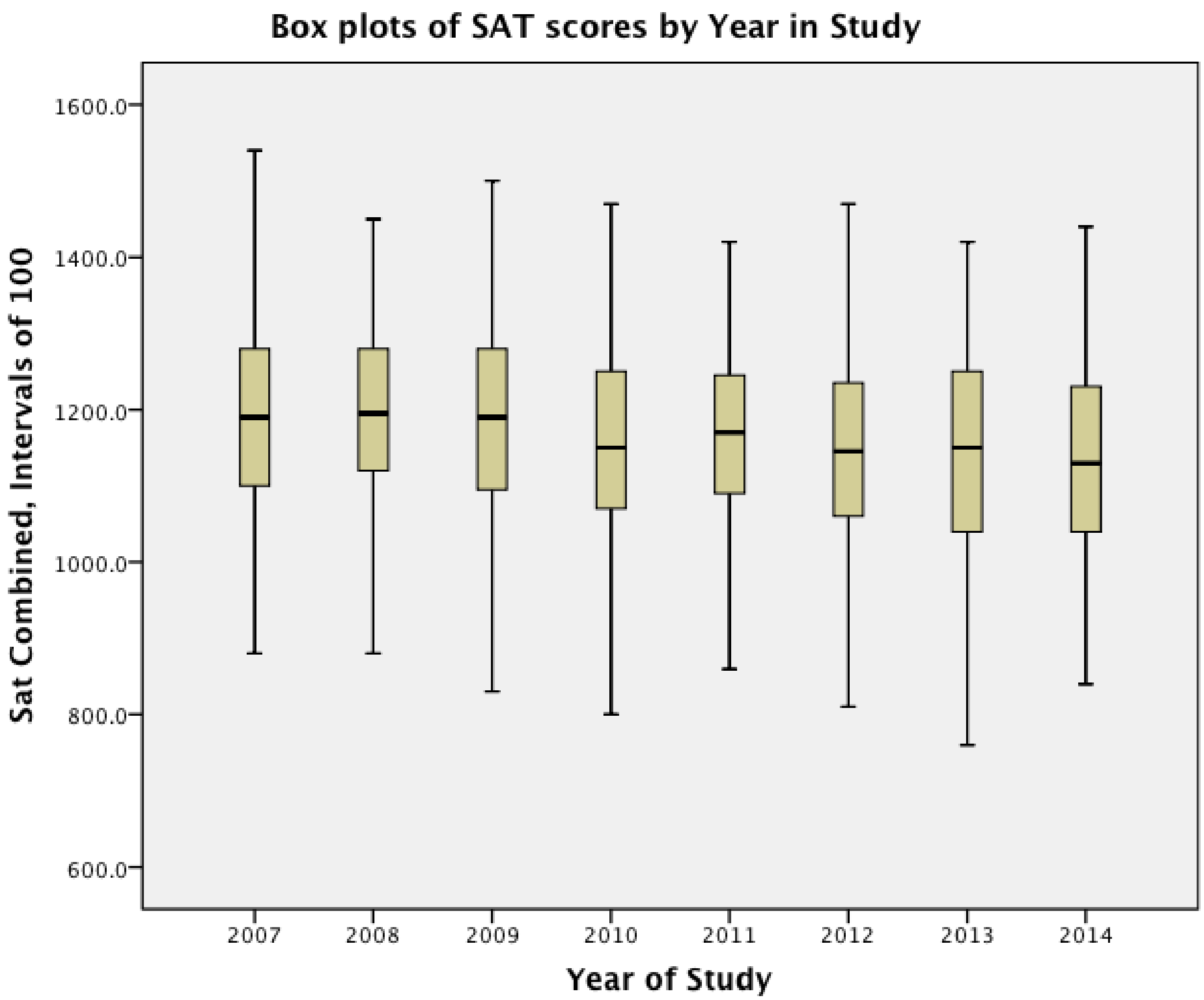


Figure 5: Boxplot of SAT scores by Year of Study

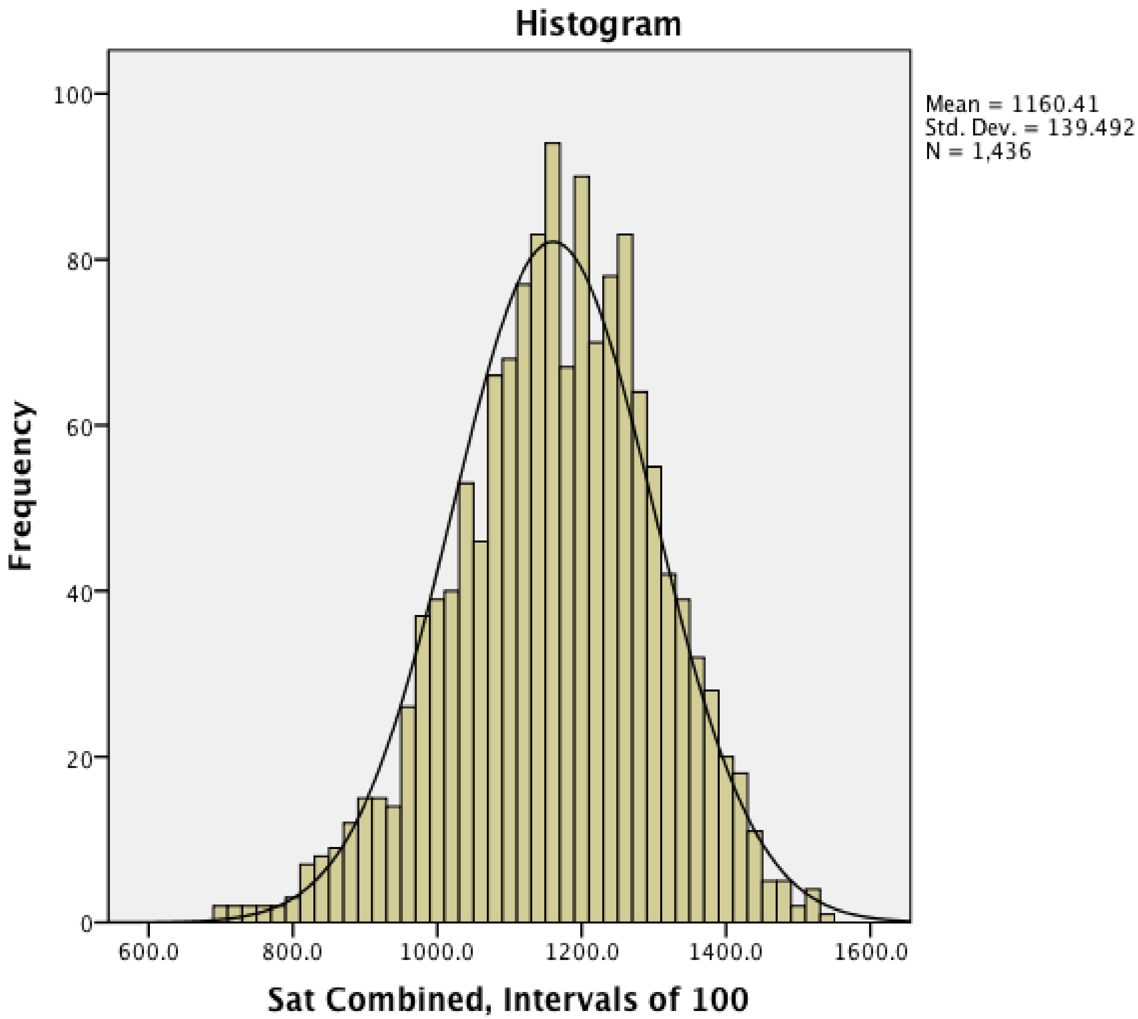


Figure 6: Histogram of SAT scores throughout study

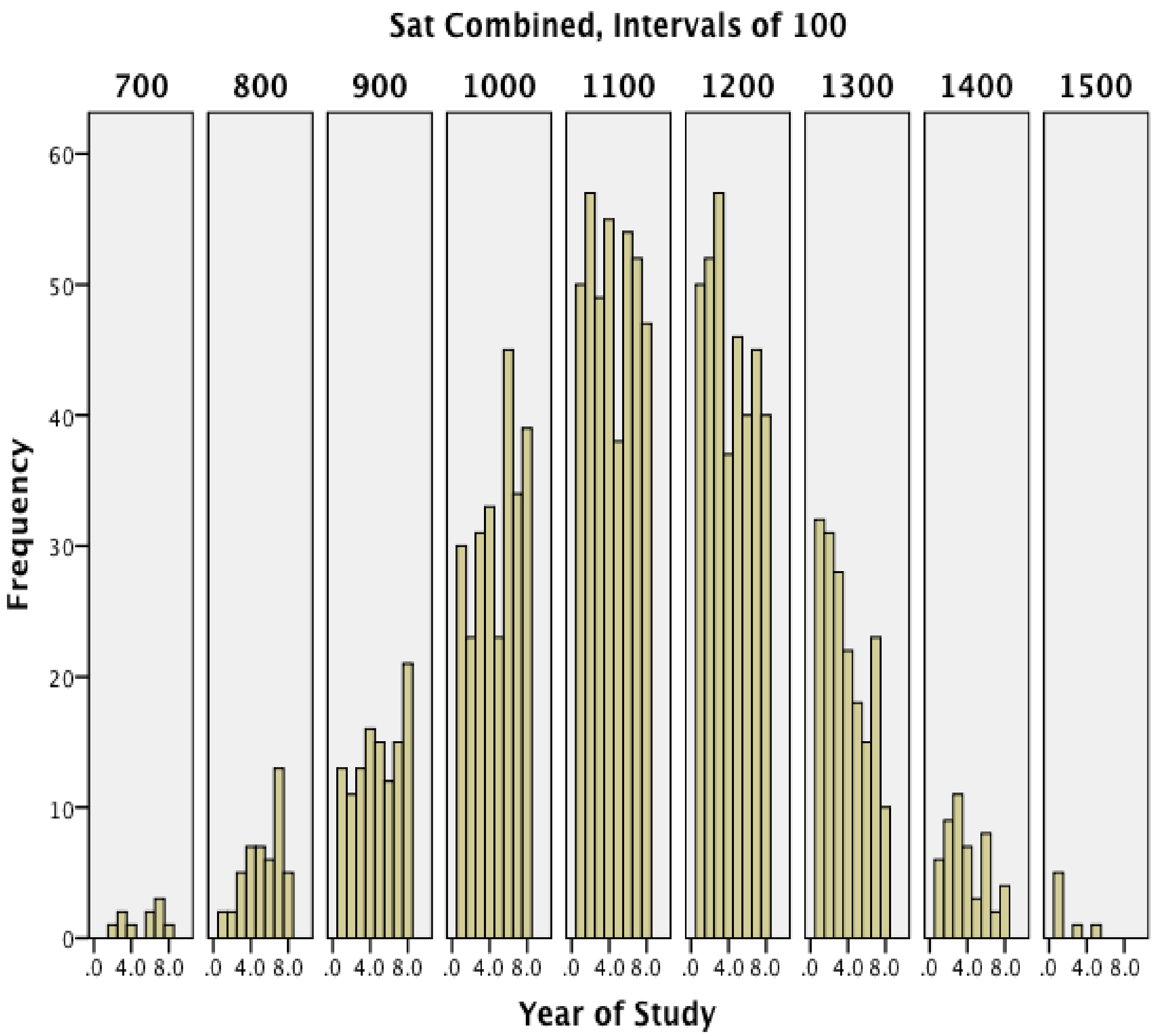


Figure 7: Histogram of SAT scores throughout study separated by year

Table 1.

Descriptive Statistics for Population Pre and Post Intervention

Variable	n (Pre , Post)	Percent of Population (Pre , Post)
Gender		
Female	475 , 489	64% , 72%
Male	264 , 189	36% , 28%
Ethnicity		
Asian	48 , 64	7% , 9%
Black/African American	47 , 92	6% , 13%
Hispanic	80 , 97	11% , 14%
White	459 , 381	62% , 55%
Unspecified	105 , 63	14% , 9%
Declared Major		
STEM	110 , 178	15% , 28%
non-STEM	629 , 519	85% , 72%
SAT Ranges		
700's	4 , 6	0.5% , 0.9%
800's	16 , 31	2% , 4%
900's	53 , 63	7% , 9%
1000's	115 , 143	16% , 21%
1100's	209 , 193	28% , 28%
1200's	195 , 172	26% , 25%
1300's	110 , 69	15% , 10%
1400's	31 , 19	4% , 3%
1500's	6 , 1	0.8% , 0.1%

Note. * n values vary in ethnicity and declared major due to students not disclosing information

Table 2.

Descriptive Statistics for Population by Year of Study:

Pre Intervention Years, 2007-2010; Post Intervention Years, 2011-2014

	Gender (%)	Ethnicity (%)	Declared Major (%)	SAT (%)
2007 (N=188)	Male: 39.4 Female: 60.6	White: 72.3 Hispanic: 8.5 Black/Afr.Am: 5.3 Asian: 2.1 Non Spec/Other: 11.7	STEM: 12.8 nonSTEM: 87.2	700: -- 800: 1.1 900: 6.9 1000: 16.0 1100: 26.6 1200: 26.6 1300: 17.0 1400: 3.2 1500: 2.7
2008 (N=186)	Male: 32.8 Female: 67.2	White: 63.4 Hispanic: 11.3 Black/Afr.Am: 5.4 Asian: 5.4 Non Spec/Other: 14.5	STEM: 12.9 nonSTEM: 87.1	700: 0.5 800: 1.1 900: 5.9 1000: 12.4 1100: 30.6 1200: 28.0 1300: 16.7 1400: 4.8 1500: --

Table 2 continued.

	Gender (%)	Ethnicity (%)	Declared Major (%)	SAT (%)
2009 (N=197)	Male: 34.0 Female: 66.0	White: 60.9 Hispanic: 10.7 Black/Afr.Am: 6.1 Asian: 8.1 Non Spec/Other: 14.2	STEM: 16.2 nonSTEM: 83.8	700: 1.0 800: 2.5 900: 6.6 1000: 15.7 1100: 24.9 1200: 29.0 1300: 14.2 1400: 5.6 1500: 0.5
2010 (N=178)	Male: 37.1 Female: 62.9	White: 51.7 Hispanic: 12.4 Black/Afr.Am: 9.0 Asian: 10.7 Non Spec/Other: 16.3	STEM: 19.1 nonSTEM: 80.9	700: 0.6 800: 3.9 900: 9.0 1000: 18.5 1100: 30.9 1200: 20.8 1300: 12.3 1400: 3.9 1500: --
2011 (N=151)	Male: 27.2 Female: 72.8	White: 57.6 Hispanic: 13.2 Black/Afr.Am: 13.2 Asian: 6.0 Non Spec/Other: 9.9	STEM: 25.2 nonSTEM: 74.8	700: -- 800: 4.6 900: 9.9 1000: 15.2 1100: 25.1 1200: 30.5 1300: 11.9 1400: 2.0 1500: 0.7

Table 2 continued.

	Gender (%)	Ethnicity (%)	Declared Major (%)	SAT (%)
2012 (N=182)	Male: 27.5 Female: 72.5	White: 51.1 Hispanic: 12.1 Black/Afr.Am: 14.8 Asian: 11.0 Non Spec/Other: 11.0	STEM: 31.9 nonSTEM: 68.1	700: 1.1 800: 3.3 900: 6.6 1000: 24.7 1100: 29.7 1200: 22.0 1300: 8.2 1400: 4.4 1500: --
2013 (N=187)	Male: 26.7 Female: 73.3	White: 55.1 Hispanic: 15.5 Black/Afr.Am: 10.7 Asian: 11.2 Non Spec/Other: 7.5	STEM: 19.8 nonSTEM: 80.2	700: 1.6 800: 7.0 900: 8.0 1000: 18.2 1100: 27.8 1200: 24.1 1300: 12.3 1400: 1.1 1500: --
2014 (N=167)	Male: 30.5 Female: 69.5	White: 54.5 Hispanic: 15.6 Black/Afr.Am: 14.4 Asian: 7.8 Non Spec/Other: 7.8	STEM: 24.6 nonSTEM: 75.4	700: 0.6 800: 3.0 900: 12.6 1000: 23.4 1100: 28.1 1200: 24.0 1300: 6.0 1400: 2.4 1500: --

Table 2 continued.

	Gender (%)	Ethnicity (%)
Summary (N=1436)	Male: 31.9 ± 4.5 [12.7]	White: 58.3 ± 6.5 [20.9]
	Female: 68.1 ± 4.5 [12.7]	Hispanic: 12.4 ± 2.2 [7.1]
		Black/Afr. Am: 9.9 ± 3.7 [9.5]
*Mean ± Std. Dev [Range]		Asian: 7.8 ± 3.0 [9.1]
		Non Spec/Other: 11.6 ± 3.0 [8.8]
	Declared Major (%)	**SAT (%)**
	STEM: 20.3 ± 6.2 [19.1]	700: 0.7 ± 0.5 [1.6]
	nonSTEM: 79.7 ± 6.2 [19.1]	800: 3.3 ± 1.8 [5.9]
		900: 8.2 ± 2.1 [6.7]
		1000: 18.0 ± 3.9 [12.3]
		1100: 28.0 ± 2.2 [6.0]
		1200: 25.6 ± 3.2 [8.5]
		1300: 12.3 ± 3.6 [11.0]
		1400: 3.4 ± 1.4 [4.5]
		1500: 0.5 ± 0.9 [2.7]

Variables

Independent variables

The following is a description of how the each of the independent variables used in this study were operationalized. Table 3 provides a summary of these variables and their measures.

Year of Study – Year of study was dually coded, first coded as 0 or 1 for pre-test and post-test respectively and then coded as 1, 2, 3, 4, 5, 6, 7, and 8 based on year in study.

SAT – SAT scores were analyzed before coding for homogeneity of variance among pre and post populations, analyzed as a continuous variable, and collapsed into increments of 100 to simplify display of data

Gender – Gender was coded 0 or 1 for males and females respectively.

Ethnicity - Ethnicity used the following codes – 0 = White, 1 = Hispanic, 2 = Black/African American, 3 = Asian, and 5 = Unknown. American Indians were originally coded 4, but due to extremely low percent of population (< 1%) they were recoded as 5 (Unknown)

Declared major - Student declared majors were coded as falling under the heading of Science, Technology, Engineering and Math (STEM = 1) or Other (non-STEM = 0).

Dependent Variable

Student class average - The dependent variable was a continuous data set, 0 to 100, representing the percent of questions correctly answered out of questions asked on exams.

Table 3.

Description of Independent Variables

Variable	Type	Measure	Code
Year of Study	Nominal	OIRA database	Pre-Intervention = 0 Post-Intervention = 1
Year of Study	Nominal	OIRA database	2007 = 1 2008 = 2 2009 = 3 2010 = 4 2011 = 5 2012 = 6 2013 = 7 2014 = 8
SAT	Continuous	OIRA database	
Gender	Nominal	OIRA database	Male = 0, Female = 1
Ethnicity	Nominal	OIRA database	White = 0, Hispanic = 1, Black/Afr. Amer. = 2, Asian = 3, Unknown/Other = 5
Declared Major	Nominal	OIRA database	non-STEM = 0, STEM = 1

Intervention

The intervention was a hybrid lecture/active learning methodology taught by two instructors. The secondary instructor (primary researcher) created the fourteen active learning lessons, modeled after POGIL activities. The proscribed formula utilized, as described previously in this thesis, included three key features:

- POGILs designed for use with self-managed teams that employ the instructor as a facilitator of learning rather than as a source of information.
- POGILs guide students through an exploration to construct, deepen, refine, and/or integrate understanding of relative disciplinary content.
- Application and development of at least one of the targeted process skills is embedded in the structure and/or content of a POGIL activity, and is not solely dependent upon the facilitation of the activity in the classroom or laboratory.

When writing a POGIL, two broad categories existed. A Learning Cycle Activity (www.pogil.org) guided the student to *develop* content knowledge through exploration, concept invention/term introduction, and application performed in the small group. An Application Activity *deepened, refined, and/or integrated* the understanding of one or more earlier concepts through application.

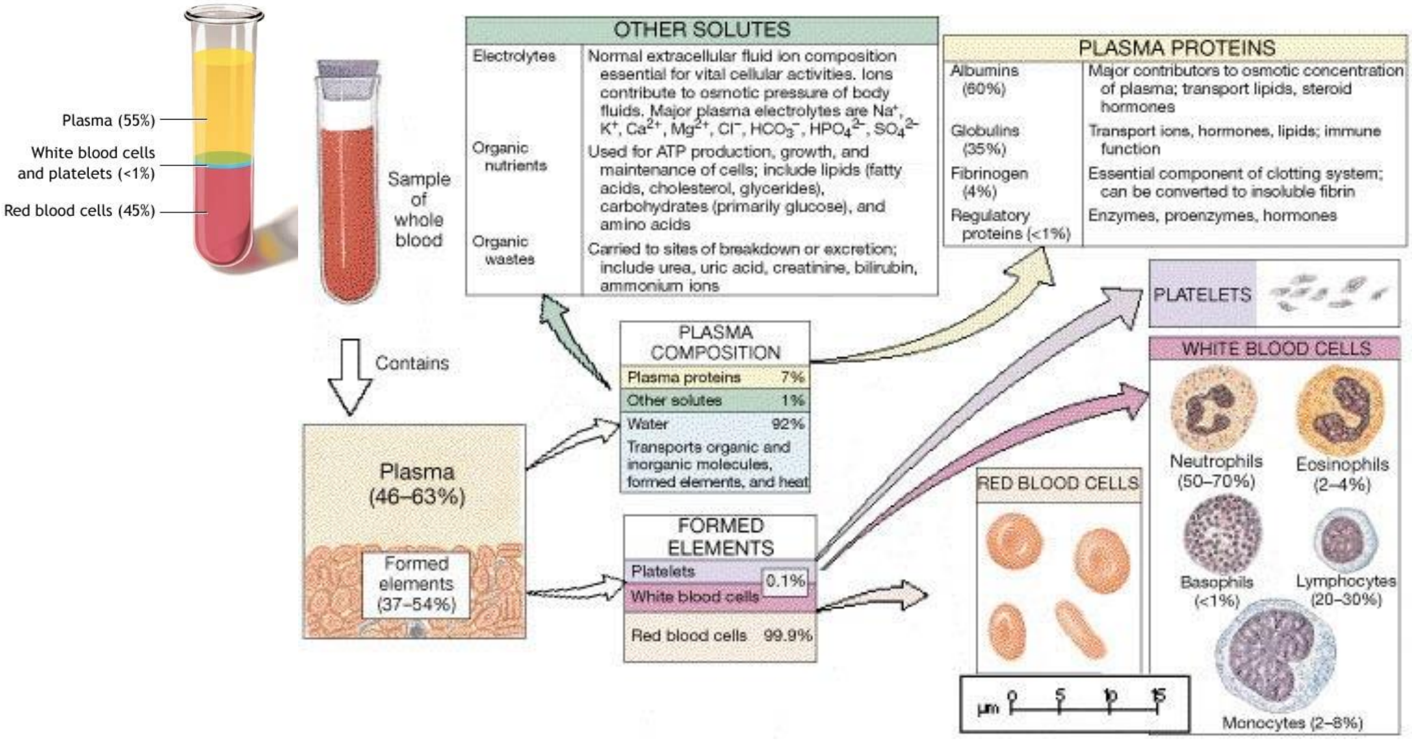
All POGIL activities included a 'model', which can be text, equation, diagram, table, graph, figure, etc. The model should target one to three content learning objectives and one to two process skills for development. The POGILs were designed to attempt to meet the targets through sequential questions (could also be actions such as filling in a table, manipulating physical objects, etc.) that clearly guided students to desired concept or process skill development. The model typically contained at least one application question with further application and practice questions may appear within the sequence of guiding questions or in an additional Exercises/Problems section.

The carefully designed POGILs ensured that the desired concept was not explicitly presented in the model, although close reading of the model to identify new concepts may occur. Students had to interact with the model, and with each other, to develop their own connections to pre-existing foundational knowledge and the insertion of the new definitions or concepts. Guidance was introduced by the instructor through additional information within the small group or presented to the entire class.

There was no specific number of exemplars provided in any model, although single exemplars were usually not sufficient in allowing students to infer a trend or pattern. There was also no specific number of exploration questions required for each model, nor specific numbers of guiding questions or practice exercises. Figure 8 depicts one of two models chosen for the lesson on the make-up of blood, followed by the sequential questions chosen by the author.

Procedures for Implementing Intervention

The class met twice a week for 80-minute sessions. The primary instructor, the same for both the pre- and post-intervention populations, lectured the first meeting of the week. Lectures included PowerPoints, similar or identical to pre-intervention instruction. The second meeting of each week had a POGIL activity scheduled and students found the activity uploaded on the course's BlackBoard website.



Questions

1. What part of blood exists in the highest percentage? The lowest?

2. Which cell exists in a larger percentage in the blood?

   What is its "job"?

   How is it important as forensic evidence?

3. Which cells exist in smaller percentages in the blood?

   What is each of their "jobs"?

Figure 8: Example of model and questions used in POGIL design

Students either brought to class printed out POGIL activity sheets to turn in at the end of class, or they download the sheet and completed in digitally sent *via* email it to the secondary instructor at the end of class. The same secondary instructor led all POGIL assignments for all four post-intervention years. The primary instructor remained present during all POGIL activities to aid in facilitation, but only the two instructors taught during the entire post-intervention period. Each activity was accessible by every student on Blackboard and a pre-course mass email sent to the class through Blackboard explained to each student the need to access the POGIL activity digitally. A syllabus was handed out that described the course schedule with lecture dates marked with appropriate POGIL activities scheduled (an example of the schedule can be found in Appendix A). Students could not immediately access all POGIL activities; the secondary instructor uploaded each POGIL only twenty-four hours before the scheduled in-lecture activity. During facilitation, the instructors noted that some students would complete the POGIL ahead of time, bringing partially completed activities to the group. This was not the intention, but waiting until class to post the activity to Blackboard was not feasible, as students would not have time to print the activity.

During the first lecture of class for the post-intervention semesters, the primary instructor described the POGIL activity ideology to the class and after approximately twenty minutes of lecture, the students implemented the first POGIL activity. The students divided themselves up based on current seats into small groups of 3 - 6 students; this study never used assigned groups due to size of lecture hall and seating arrangement of the facility. During sequential classes, the facilitators noted that students continued to sit in their original groups, or relocated in the lecture hall until they found a group that fit their needs. This study did not use assigned roles within a group; all students potentially presented portions of the activity to the class (as a recorder/presenter) to attempt to ensure each student remained engaged in the group. The facilitator observed groups were self-motivated to assigning roles during each class, often altering roles naturally to ‘share the workload’.

After visually displaying the POGIL on the classroom’s projection large screen, the facilitator presented a brief description of the model before releasing the class to work in their small groups. Upon allowing students to start group work, the instructor walked around the lecture hall watching the groups as members questioned each other, and looked through the models. The instructor kept on guard for obvious signs of confusion when a group would need assistance. When observations of the multiple groups indicated the majority of students finished the model, the instructor returned to the front of the class and groups orally reported answers. The facilitator chose volunteers, and if only the same groups seemed willing to answer, the facilitator looked for particular students to engage, if possible.

The sharing/reporting proceeded at a better pace when volunteers raised hands to answer – an alternative was to have multiple students come forward and report on numerous white boards around the room, but the lecture hall in this study was not conducive to this style of reporting. During facilitation, the instructor noted groups that had correct answers, or asked specific questions that the entire class could benefit by hearing. The facilitator deliberately chose groups if no new volunteers offered to report, or if the point made in a small group was of enough educational significance to warrant calling out a group during or after reporting. If the POGIL activity had multiple models, each model was assigned, finished, and reported on before moving on to the next.

A mini-lecture done by the primary professor, which usually took between 20 - 40 minutes, preceded the POGIL activities. The weekly activities matched a predetermined schedule that correlated to laboratory work. Students physically turned in completed POGILs at the end of class or emailed the activity to the professor to verify all group members recorded answers. The secondary instructor returned all collected hard copies of the completed POGILs within a week of the lecture but assigned no grades except to record which students completed the activity. Students were encouraged to work on the POGILs outside of class and email completed activity to the secondary instructor for verification if they were absent from the lecture. Students were also encouraged to compile POGILs completed during the course as they provided an excellent source of reviewable material for an examination. All POGIL activities created for this course are provided in Appendix A following an example schedule of use.

Instrumentation

The instruments used for the dependent continuous data were multiple-choice exams given throughout the semester of enrollment. Instructors timed all exams, the first three exams completed within 80 minutes (a normal class lecture) and based only on the information covered during an increment of the semester, and two hours allowed for the final, which was cumulative and comprehensive. Students recorded all answers on scantrons and the instructor sent the scantrons to OIRA for grading and item analysis.

Hourly Exam 1

The multiple-choice examination based on material taught from the first five chapters of the chosen textbooks. Material covered and tested included:

- an introduction to forensic science;
- the scientists accredited for the groundwork attributed to forensic science;
- the precedent court cases establishing guidelines for evidence allowed in court;
- steps taken when establishing a secure crime scene;

- specific jobs of personnel analyzing the crime scene;
- types of experts that may be called upon during analysis of evidence;
- the difference between science and pseudo-science;
- the identification of qualitative v. quantitative data collection;
- establishing if the evidence has individual v. class characteristics;
- types of microscopy used during analyses and which microscopy best suits which evidence;
- identifying biological evidence at a crime scene;
- determining if that evidence can provide DNA to an analyst;
- central dogma of molecular biology;
- specific tests run on DNA evidence (PCR, RFLP, STR, VNTR and gel electrophoresis) and how to understand the results of such tests.

Hourly Exam 2

The multiple-choice examination based on material taught from the next four chapters of the chosen textbooks. Material covered and tested included:

- the study of blood and the cells and particulates found in blood;
- the four questions asked and answered by a serologist analyzing a crime scene;
- the fluid motion of blood and the analysis of blood spatters;
- how fingerprints and body prints are created by the body;
- the analysis of fingerprints to include both types and minutiae;
- the difference between latent, visual, and plastic prints and the techniques used to expose, collect, and preserve each;
- the biological structure of hair and how it is microscopically analyzed;

- the difference between hair samples and fiber samples that can be collected;
- types of fibers to include a variety of natural and synthetic fibers;
- coroner v. medical examiner systems;
- autopsy examinations;
- manner, cause, and mechanism of death;
- types of wounds and the weapons most likely to create such a wound;
- the biological profile created by a forensic anthropologist;
- the most often examined bones to analyze sex, ancestry, height, and pathologies of decedent.

Hourly Exam 3

The multiple-choice examination based on material taught from the next four chapters of the chosen textbooks. Material covered and tested included:

- science of ecology;
- subsets of forensic ecology;
- stages of decay;
- study of entomology to determine post mortem index;
- atomic theory;
- introduction to bonding of atoms;
- chromatographic methods available to separate mixtures;
- application of chromatographic methods to evidence;
- types of spectrometry used to identify matter and when to apply which methods;
- pharmacodynamics v. pharmacokinetics;
- toxin v. drug;

- types of poisons;
- the controlled substance act and the scheduling of drugs;
- the classification of drugs based on effects on human body;
- the chromatographic and spectrometric analyses performed when evidence is drug-based;
- study of the physical and chemical properties of glass, soil, and paint;
- types of explosives;
- the application of oxidative reactions to arson.

Final Examination

The multiple choice comprehensive exam of all material previously covered in class with a slight emphasis on material covered during "untested' the last weeks of material encompassing the final three chapters of the chosen textbooks that were tested in the earlier three hourly examinations. In addition to the work covered in the previous examinations, the final portion of material covered and tested included:

- an overview of physical measurements;
- types of firearms and the creation of rifling patterns;
- the effect of manufacture of firearms on ballistics;
- the evidence that can be collected from bullets v. casings and gun powder residue;
- the use of document and voice analysis;
- the application of forensic psychology.

As much as possible, the instructor followed the same schedule from year to year, using the same textbooks and Powerpoints. Due to circumstances beyond the control of the instructors, slight deviations from the above descriptions did occasionally occur. The data inputted into SPSS included percentile scores for each of the four exams as well as an additional variable, summative exam score, where all multiple-choice questions given during the semester were totaled and turned into a percent correct measurement. Only summative exam scores were included after Pearson Correlations demonstrated a single student class average accurately represented the correlation among exam scores.

The student class average was only a valid construct when the responses combined were reliably measuring the same underlying construct. The scores of the four tests were averaged to compute the new variable identified as Student class average. To verify that each of the sub tests reliably measured a given student's competence – similar performances on all four tests through the year with no scores too high or low compared to others – Cronbach's alpha was calculated (Table 4). The new variable was considered to have reasonable internal consistency reliability if the reliability coefficient, alpha, was above 0.7 (Leech *et al*., 2008). All of the computed Cronbach's alphas for the exams within each of the eight years of the study were above 0.7. Due to this reliability analysis, the researcher deemed the new variable, Summative Student class averages, appropriate for the sequential regression analyses performed next.

In addition to visual inspection of the histogram, skewness statistics were also calculated to assess the approximation of normality. The skewness for this variable was found to be less than plus or minus one (= - 0.356), indicating that the dependent variable was not significantly skewed and was approximately normal (Leech *et al*., 2008). The descriptive statistics for the dependent continuous variable, given in Table 5, have also been provided as histograms in Appendix D. Table 6 offers descriptive student class averages broken down by identified student descriptors.

Table 4:

Reliability Statistics for Instrument

Year	Alpha
2007	0.812
2008	0.844
2009	0.844
2010	0.765
2011	0.814
2012	0.818
2013	0.833
2014	0.806
Overall	0.773

Table 5:

Description of Dependent Variable, by Exam

	Mean	Minimum	Maximum	Std. Deviation	Skewness
Exam 1	72.5	30.0	100.0	12.8	-.400
Exam 2	69.2	20.0	100.0	13.4	-.471
Exam 3	68.3	23.5	100.0	13.5	-.301
Exam 4	70.0	23.8	100.0	12.5	-.245
Yearly Average	70.0	35.8	95.0	10.0	-.356

Table 6.

Descriptive Statistics for Student Class Averages Separated by Population

Pre Intervention Years, 2007-2010; Post Intervention Years, 2011-2014

Variable		Pre	Post	Observed Change
Gender				
	Male	68.67	69.83	+ 1.16
	Female	68.77	72.00	+ 3.23
Ethnicity				
	White	69.72	72.83	+ 3.11
	Hispanic	63.88	68.83	+ 4.95
	Black/Afr. Am.	62.99	67.93	+ 4.94
	Asian	72.51	70.55	- 1.96
Declared Major				
	nonSTEM	67.99	70.24	+ 2.25
	STEM	72.92	74.80	+1.88
SAT				
	700	54.11	62.01	+ 7.90
	800	58.48	61.03	+ 2.55
	900	59.20	66.62	+ 7.42
	1000	64.38	68.71	+ 4.33
	1100	68.87	72.80	+ 3.93
	1200	70.68	73.43	+ 2.75
	1300	73.35	75.70	+ 2.35
	1400	77.21	81.20	+ 3.99
	1500	72.97	62.32	-10.65

Included in the analysis of student class averages is the potential for exam scores to increase over time due to variations in teaching experience and student study habits as they progress from their freshman to their senior year. A visual examination of the student averages from year to year, provided in Figure 9, connoted little to no visible consistent increases in class averages attributed to potential time effects.

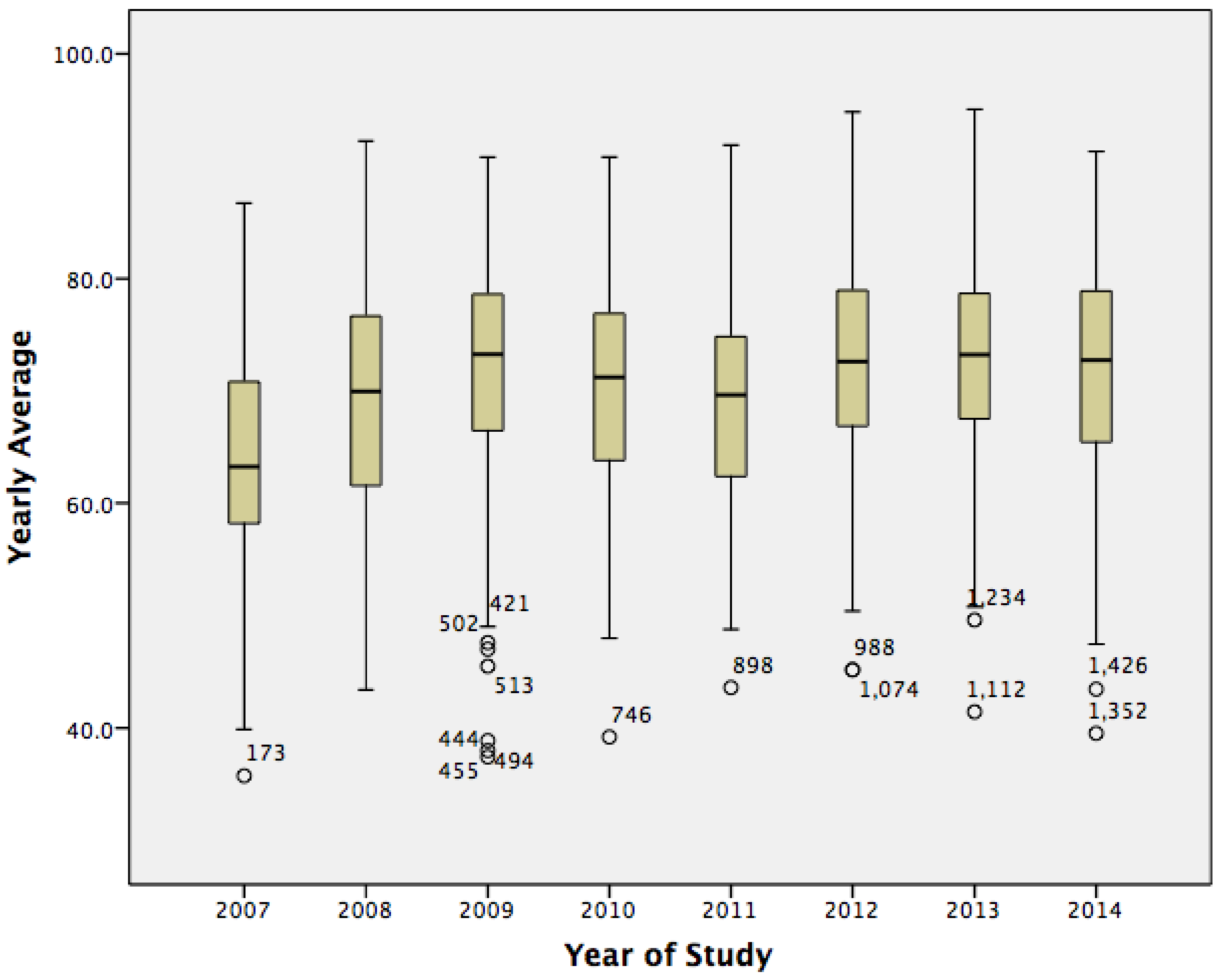


Figure 9: Boxplot of Student Class Averages Yearly, 2007-2014

Regression Analysis

Before the final regression analysis was completed, we tested each variable against the student class averages in General Linear Model univariate studies to determine significance as a variable. If the variable demonstrated significance, it was included in the sequential regression models that followed. The goal of the regression analyses were to examine the relationships between averaged yearly exam scores and the use of a hybrid active learning methodology, including the following student descriptors as possible covariates – gender, ethnicity, Stem or non-STEM declared majors, and SAT scores. The analysis used SPSS version 21 for the descriptive and inferential statistics.

The data analysis began by visually inspecting all data from the OIRA data set to assess any possible outliers. During this inspection, we found and eliminated two cases from the study. We used coded variables and descriptive statistics to analyze demographic characteristics of the student descriptors identified as possible covariates in the study. After performing reliability analysis on the four exams given during each semester, using Cronbach's Alpha, researchers established the use of a new variable, the average of yearly exam scores, as the continuous dependent variable.

The first step in the regression analysis was to look at each variable individually, before investigating relationships to other variables, by employing summary statistics and exploratory graphics. The analysis ultimately planned was an ANCOVA, or analysis of covariance. This form of regression examines a continuous dependent variable (Student class average) and considers its relationship to at least one continuous independent variable (SAT combined) and at least one categorical variable (Intervention). The validity of the inferences drawn from an ANCOVA test depends on the degree to which the key assumptions met the underlying analysis.

The assumptions considered in this study are: 1) the observations are independent of each other, 2) linearity exists between the dependent variable and the continuous variables, 3) within each treatment group the dependent variable is normally distributed, and 4) the variance for the dependent variable within each treatment group is the same. Multiple regression is often seen as the preferred analytical method in the social sciences when an explanation of the variance observed in phenomena must also include a variation in other variables (Keith, 2006).

We initially explored the identified independent variables, operationalized as previously described in this chapter, and explored their relationship to the dependent variable as pairs of data, allowing several considerations. First, this approach allows further insights into how well the data met the first three key assumptions. Secondly, it develops an idea of how strongly each of the potential independent variables related to the dependent variable. A common threshold to the inclusion of an independent variable in multivariable analyses is an alpha (*p* value) of 0.15, and then in the final analysis, all retained variables remain significant at an alpha of 0.05. Each paired data exploration included a boxplot, a general linear model (GLM), and a Tukey *post hoc* analysis. To look for relationships between two continuous variables, we performed a Pearson correlation and/or a simple linear regression. A graphical representation seen in scatterplots, and the recorded coefficient of determination (R^2) for the relationships' explanation of observed variability, supported identified relationships between variables.

After exploring all variables individually first, looking carefully for significant relationships, researchers created a multivariate model. Based on screening several multivariate models, all potentially significant variables were included in the final multivariate model. Significant variables remained in the multivariate model, when the *p*-value was less than 0.05. Analysis of the ANCOVA results illustrated how well the final multivariate model explained the separate contributions of each significant variable on exam scores. The R^2 change helped to determine if student predictors could explain the amount of variance in exam scores. The regression coefficients analyzed determined which of the variables significantly contributed to exam scores the most as well as to what extent student predictors affected exam scores and not the created intervention. The goal of this analysis was to gain a better understanding of the ability of active learning lessons to change exam scores in equitable populations and to determine which student predictors to consider when incorporating alternative teaching methodologies in science education. Following the final linear regression model, analysis of the predicted values and residuals allowed assessment of model validity.

Summary of Chapter Three

This research study sought to examine potential relationships between use of active learning pedagogy on student class averages and the potential interactions between student descriptors and the intervention of active learning. Data collected included student descriptors, operationalized for use, and exam scores earned by students. Data analyses presented in this chapter include descriptive statistics for the population broken into the key study variables. We established a single alternate dependent variable from four exam scores to a single class average, and related the pre and post-intervention student class averages related to the student descriptors explored. The next chapter will present results from the ANCOVA analysis.

Chapter Four: Quantitative Data Analysis

The purpose of this causal-comparative/quasi-experimental study was to assess the effect of using active learning strategies (POGILs) in a forensic science survey course, examining the effect of the course created POGIL activities on student class averages. This chapter presents the results and analysis of this study including interpretation of the findings. A sequential multiple regression of the data was employed to assess how the use of a hybrid lecture/active learning environment effects student class averages and to incorporate the impact of chosen student descriptors.

Findings from Research Questions

The goal of this study was to examine the effect of an intervention on assessment scores, as well as examining student characteristics that may have confounded the observed effect. The initial hypothesize was that the intervention would statistically raise the exam scores of the average student.

Based on review of gender effects on science learning, the observed increase of exam scores between genders would be expected to be unequal with an obvious outcome difference observed; female students would be expected from this literature to have higher class averages than their male counterparts' averages using active learning (Wyller, 2002), although both genders would experience an increase.

Ethnicity was a student characteristic also reported in previously described studies as having a potential impact on student class averages. In this case, the hypothesis was that observable variation in the changes seen in exam scores would occur, with Black/African American and Hispanic students demonstrating the highest increase in student averages and Asians the least (Freeman *et al*., 2008). This hypothesis examining the effects of ethnicity predicted all ethnicities would experience an increase, but that variations among the ethnic groups would be observed.

A difference was further expected to be seen based on the students declared major being in a STEM field or not, with non-Stem majors experiencing a higher increase through active learning than STEM majors, although both would show increases. Past research on science literacy based on personality traits attributed to STEM and non-STEM students precipitated this hypothesis (Jin & Bierma, 2013).

Literature descriptions of students most impacted by active learning methods suggested that students with lower SAT scores would be more inclined to find active learning useful in learning and retention. Therefore, when examining the effect on SAT scores, the hypothesis was that students in lower ranges of SAT scores would experience the highest increase, with the changes increasing as SAT scores increased, maximizing at a particular SAT level and then decreasing in effect.

Bivariate General Linear Model

Perhaps the most important assumption underlying the use of multiple regression is the necessity of a linear relationship between independent variables and the dependent variable to correctly estimate the relationship between these variables (Keith, 2006; Osborne & Waters, 2002). In our work, we developed boxplots to assess the potential differences between student class averages of each nominal variable (Figures 10, 11, 12, and 13) and a scatterplot matrix to assess the linear relationship between the two continuous variables proposed in this analysis (Figures 14). Inspection of the boxplots indicated variations within nominal variables were present and the scatterplot indicated that linear relationship met the assumption as a straight line fits the plot as opposed to a curved line (Leech *et al*., 2008). An inspection of the histogram and Normal P-P plot of the standardized residuals also indicated a linear relationship meeting the assumption for linearity (Osborne & Waters, 2002).

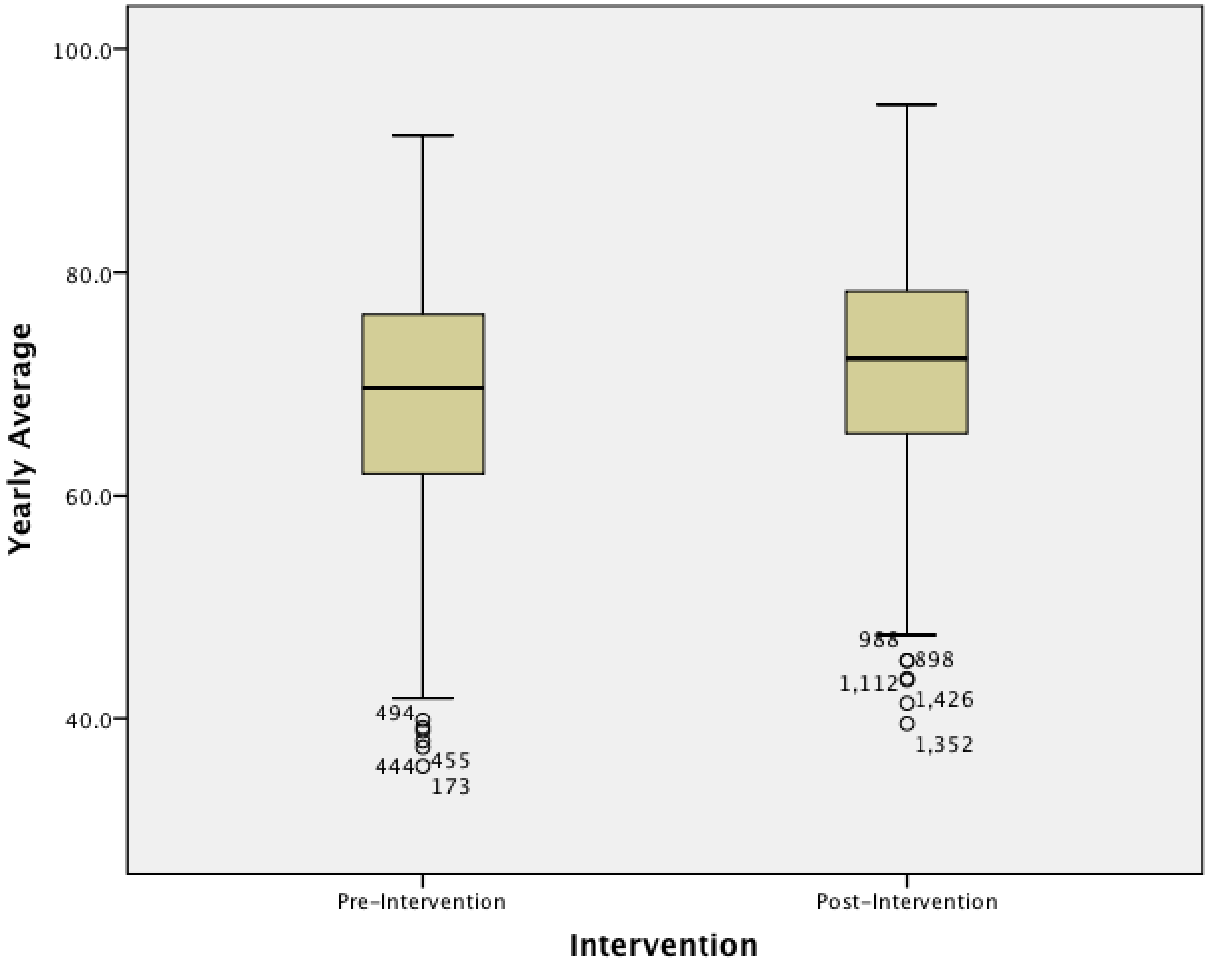


Figure 10: Boxplot of Student class average vs. intervention

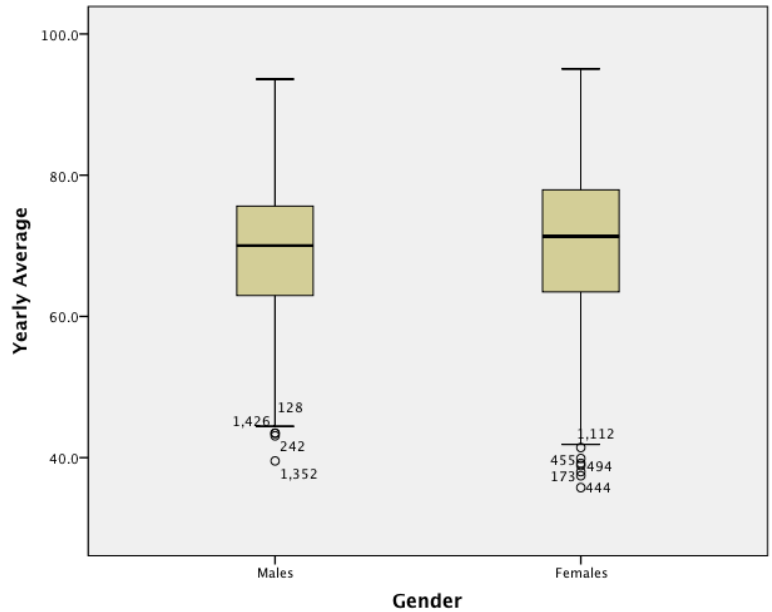


Figure 11a: Boxplot of Student class average vs. gender

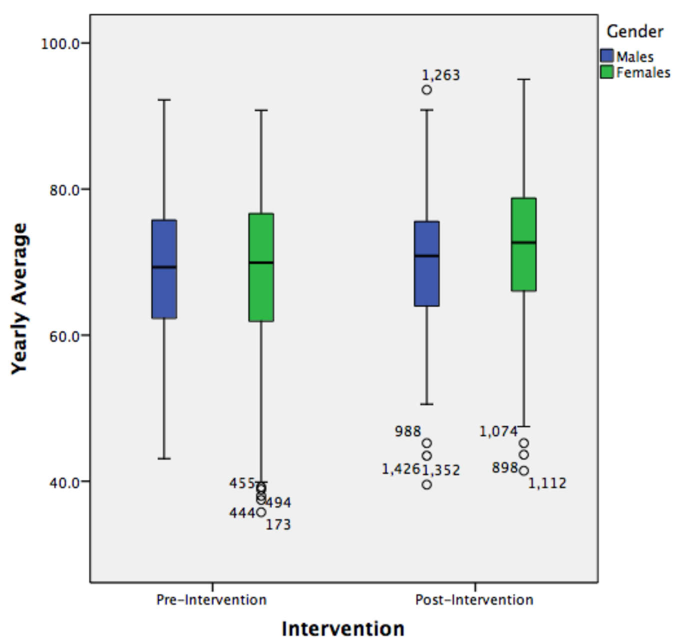


Figure 11b: Boxplot of Student class average vs. gender, separated by intervention

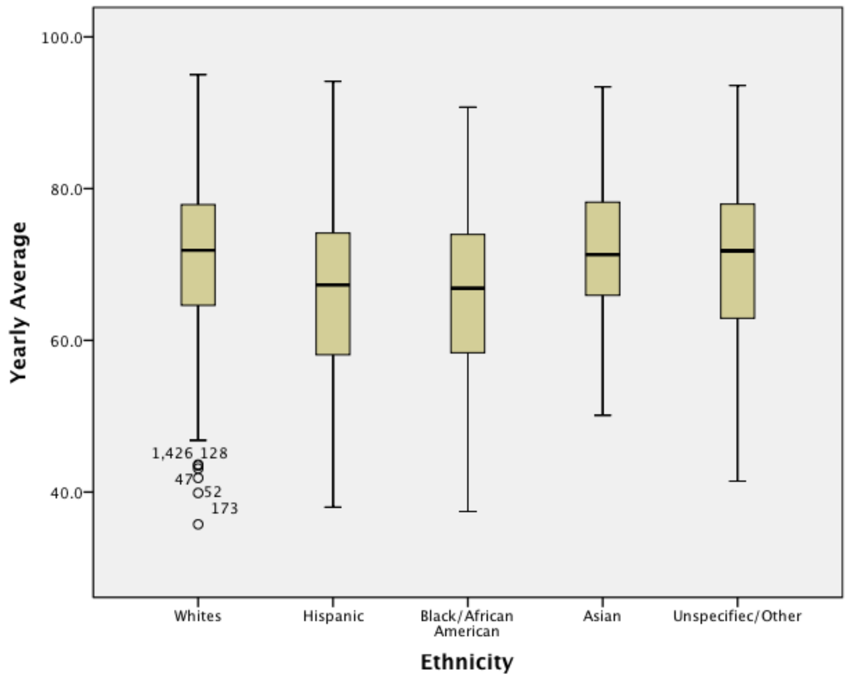


Figure 12a: Boxplot of Student class average vs. ethnicity

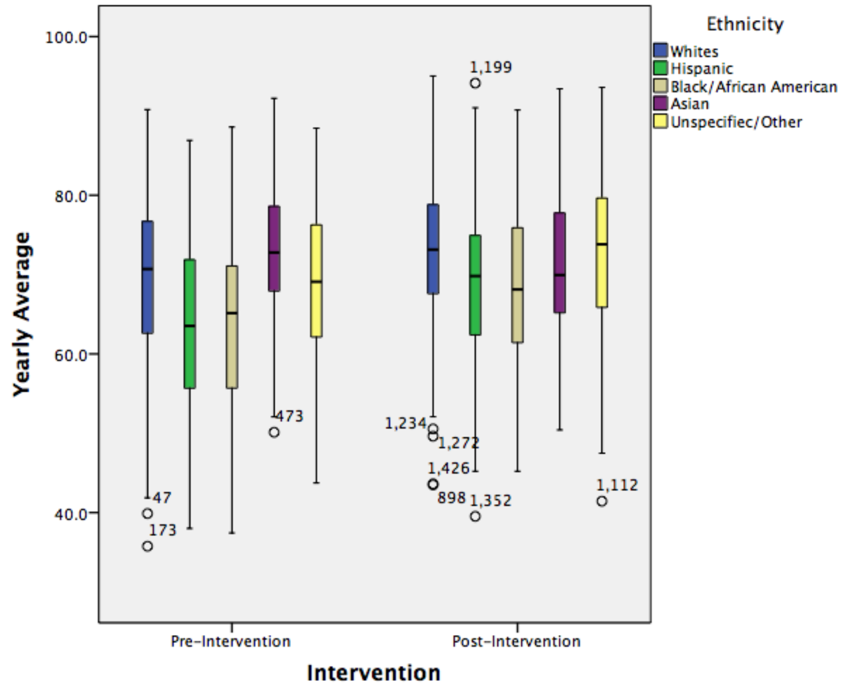


Figure 12b: Boxplot of Student class average vs. ethnicity, separated by intervention

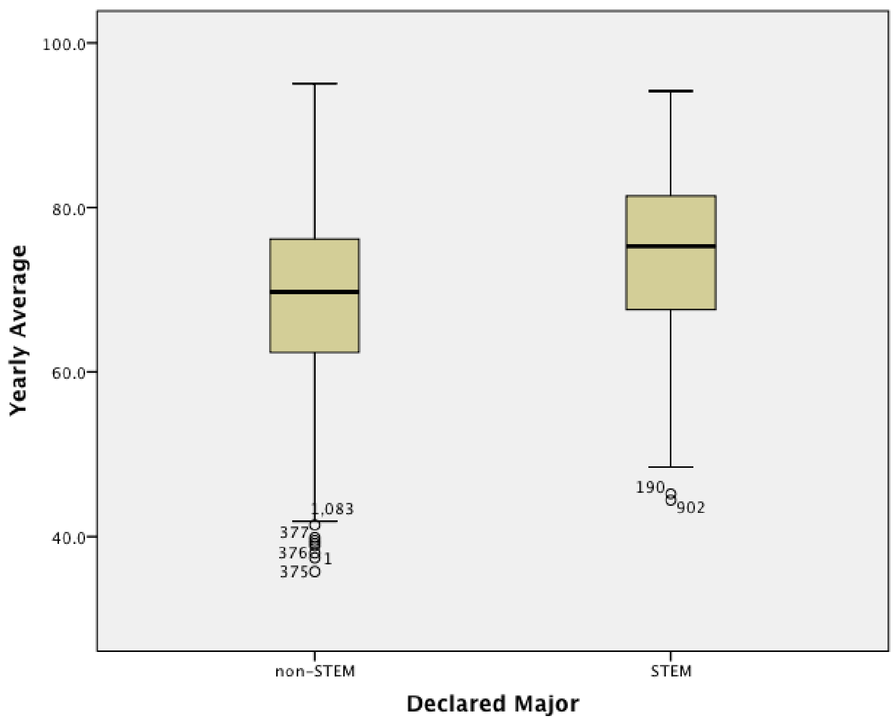


Figure 13a: Boxplot of Student class average vs. declared major

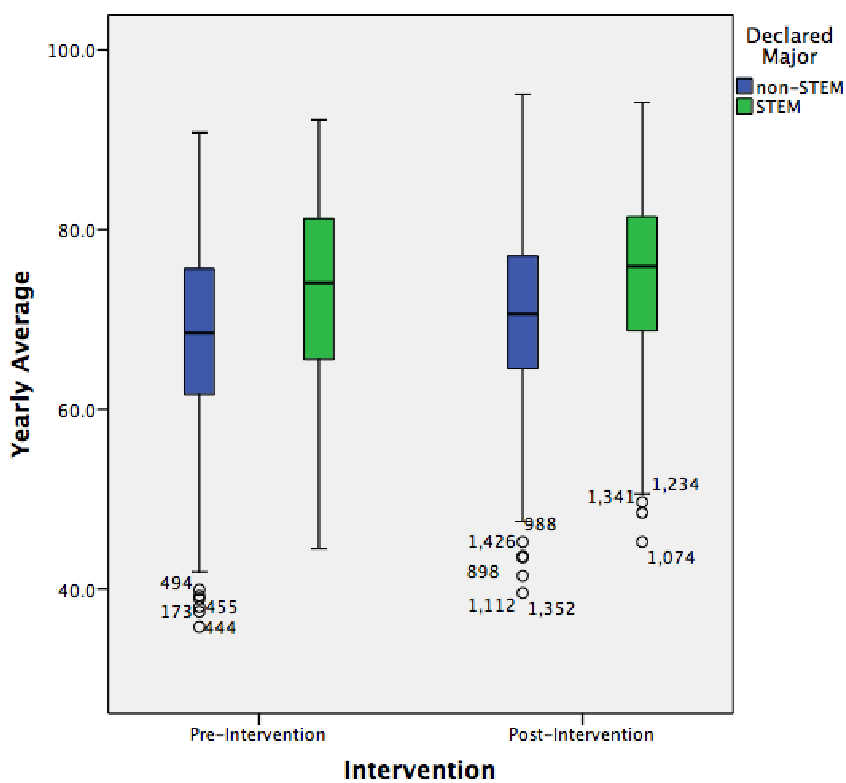


Figure 13b: Boxplot of Student class average vs. declared major, separated by intervention

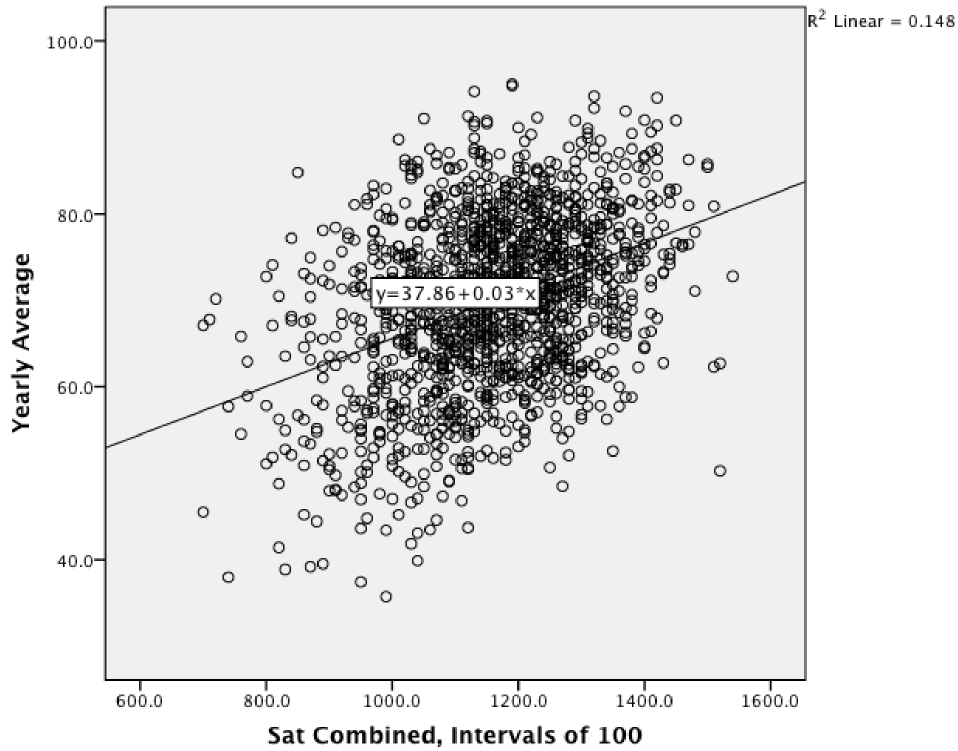
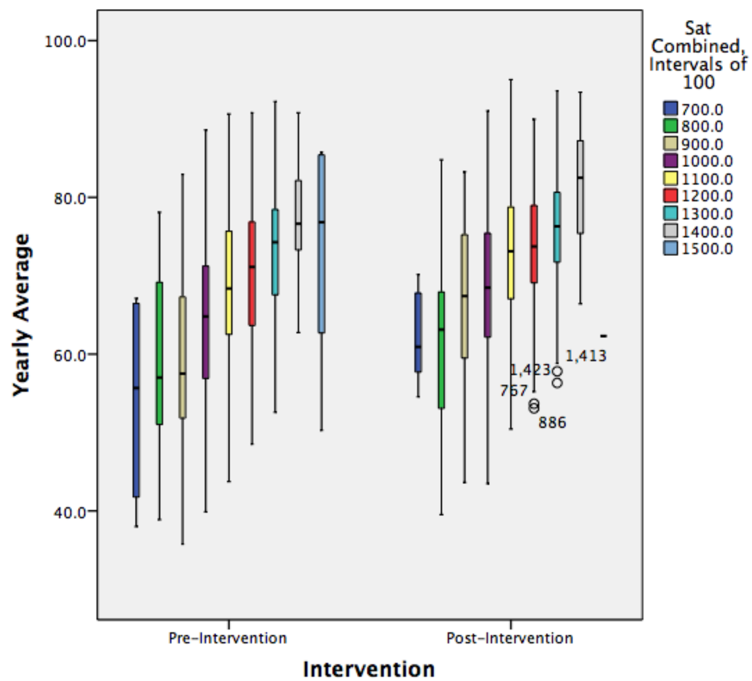


Figure 14a: Scatterplot of Student class average vs. SAT



When considering the relationships between the dependent and independent variables, the bivariate stage of the analysis provides several types of valuable information. An idea of how strongly each of the potential independent variables related to the dependent variable is determined and this provides access to the necessary steps in ultimately determining which variables need to be included in the multivariate work due to the presence of multicollinearity. When using various independent variables in the prediction or explanation of a dependent variable, multicollinearity occurs when independent variables are highly inter-correlated, providing some of the same information (Leech *et al*., 2008). How much these variables overlap and the degree to which they correlate can lead to misinterpreting the results in the regression analysis (Keith, 2006). A summary of the ANOVA bivariate screening data is provided in Table 7. We chose ANOVA regression analyses for the bivariate analysis due to the continuous dependent variable and the nominal independent variables. The exception to this was the analysis of student class average vs. SAT scores, due to the continuous nature of both variables; a Pearson Correlation was performed instead of an ANOVA. Levene's Test of Equality of Error Variances were recorded for each bivariate, as well as boxplots of the bivariate interaction. All details for bivariate analyses have been provided in Appendix E.

Table 7.

Summary ANOVA bivariate screening of Independent and Dependent Variables

	df	F	*p*	R^2
Yearly Avg & Intervention	(1,1434)	25.46	.000	.017
Yearly Avg & Gender	(1,1434)	4.90	.027	.003
Yearly Avg & Ethnicity	(4,1431)	13.56	.000	.037
Yearly Avg & Declared Major	(1,1434)	60.86	.000	.041
Yearly Avg & SAT Combined	(1,1434)	.384**	.000	.148

**Pearson Correlation, not F statistic

ANCOVA regression

Adjusting treatment effects for confounding variables is important for accurately determining the value and practical usefulness of treatments, interventions, and programs (Arvey, Cole, Hazucha, & Hartanto, 1985; Grant & Wall, 2009; Harwell, 2003; Maris, 1998; Schafer & Kang, 2008). During the creation of the final model demonstrating statistically significant single and multicollinear effects on the student class average, all nominal independent variables were included as factors and SAT scores were considered the covariate against the dependent variable, Student Class Averages.

Since all nominal variables (intervention, gender, ethnicity, and declared major) were significant at the 0.15 level, as seen in Table 7, they were initially included in the first ANCOVA model, under a full factorial analysis, before custom models were built and factors were hand selected for inclusion. The results of the tests of between subject effects have been provided in Table 8, using the full factorial analysis. The descriptive statistics for the initial model has been provided in Appendix F.

Table 8.

Tests of Between Subjects Effects; Initial ANCOVA, full factorial

Source	*df*	F	*p*	R^2
Intervention	1	6.155	.013	.005
Ethnicity	4	.827	.508	.003
Gender	1	6.409	.011	.005
SAT Combined	8	12.106	.000	.073
Major	1	9.499	.002	.008
Interv*Ethnic	4	1.041	.385	.003
Interv*Gender	1	.130	.719	.000
Interv*SAT	8	1.628	.112	.011
Interv*Major	1	.195	.659	.000
Ethnic*Gender	4	.651	.626	.002
Ethnic*SAT	24	1.026	.428	.020
Ethnic*Major	4	1.696	.148	.006
Gender*SAT	8	.727	.668	.005
Gender*Major	1	1.148	.284	.001
SAT*Major	7	.738	.640	.004
Inter*Ethnic*Gender	4	1.234	.295	.004
Inter*Ethnic*SAT	21	1.237	.210	.021
Inter*Ethnic*Major	4	.636	.637	.002
Inter*Gender*SAT	6	.702	.648	.003
Inter*Gender*Major	1	1.795	.181	.001
Inter*SAT*Major	6	.974	.442	.005
Ethnic*Gender*SAT	19	1.417	.109	.022
Ethnic*Gender*Major	4	1.510	.197	.005
Ethnic*SAT*Major	16	1.054	.693	.014
Gender*SAT*Major	6	.768	.595	.004
Inter*Ethnic*Gender*SAT	11	1.637	.083	.015
Inter*Ethnic*Gender*Major	3	.117	.950	.000

Table 8 cont.

Tests of Between Subjects Effects; Initial ANCOVA, full factorial

Source	*df*	F	*p*	R^2
Inter*Ethnic*SAT*Major	9	.440	.914	.003
Inter*Gender*SAT*Major	4	1.060	.375	.003
Ethnic*Gender*SAT*Major	7	1.619	.126	.009
Inter*Ethnic*Gender*SAT*Major		-	-	.000

As seen in Table 8, the highest *p* values were seen in *Inter*Ethnic*Gender*SAT* and *Inter*Ethnic*SAT*Major*, and both were removed from the full factorial as the first custom model was developed. Twenty-two total custom runs were analyzed, the highest *p* value(s) being removed each time and ethnicity was removed from the model after custom run 5 due its lack of significance (0.556). Leech *et al*. (2008) advised to eliminate problematic variables if it does not make conceptual sense to combine the variables, particularly in a situation in which the variable has a low correlation with the dependent variable and stands to reduce the power of the analysis. Ethnicity was the only descriptor removed from the model, yet all multicollinear interactions showed significance levels above 0.05 and were ultimately removed. The final custom model, therefore, only examined the main effects of intervention, gender, declared major, and SAT scores. The results of the final model are shown in Table 9 with a summary of the final model including parameter estimates shown in Table 10. The parameter estimates identify the observed/predictive difference between the pre and post intervention population student averages.

Table 9.

Tests of Between-Subjects Effects, Final Custom Model

Source	*df*	F	*p*	R^2	Observed power[b]
Corrected Model[a]	4	111.748	.000	.276	1.000
Intervention	1	43.019	.000	.029	1.000
Gender	1	13.698	.000	.009	1.000
Major	1	91.918	.000	.060	0.959
SAT	1	345.026	.000	.194	1.000

a. R Squared = .276 (Adjusted R Squared = .274)
b. Computed using alpha = .05

Table 10.

Summary of ANCOVA, final custom model, including Parameter Estimates

Source	*df*	F	*p*	R^2	β
Intervention	1	43.02	.000	.029	
Pre					0[a]
Post					+3.1
Gender	1	13.70	.000	.009	
Male					0[b]
Female					+1.9
Major	1	91.92	.000	.060	
non-Stem					0[c]
STEM					+5.6
SAT	1	345.03	.000	.194	+3.1 every 100 pts

a. mean of 69.9 as standard of 0
b. mean of 70.5 as standard of 0
c. mean of 68.6 as standard of 0

The final model in the ANCOVA regression demonstrated that the intervention remained significant as affecting the student class averages of students. On average, the intervention significantly altered exam scores [F (1,1431) = 43.019, $p< 0.000$, $R^2=0.029$] raising student averages 3.1%, the exact amount seen between students with 100 point difference on their SAT scores. When considering student characteristics (gender, ethnicity, the declared major, and the SAT scores of students), only gender, declared major and SAT remained significant as influencing the student class averages of students.

In the population, females outperformed their male counterparts by 1.9%, although both genders were significantly affected by the intervention [F (1,1431) = 13.698, $p< 0.000$, $R^2=0.009$]. Students with declared majors in the STEM fields outperformed the non-STEM fields by 5.6%, a strong factor in the model [F (1,1431) = 91.918, $p< 0.000$, $R^2=0.060$]. Predictably, the SAT scores, however, showed the strongest effect [F (1,1431) = 345.026, $p< 0.000$, $R^2=0.194$] where an increase of 3.1% in the student class averages could be seen for every 100 points earned on the SATs.

Upon completion of the final model, both unstandardized predicted values and residuals were saved to test the final model assumption of normality. The scatterplot created from the unstandardized predicted values and residuals is given in Figure 15. The fact that the best-fit line in this scatterplot is horizontal demonstrates the lack of pattern between the residuals and predicted values and was considered an indication that the model was valid. A second test for homoscedasticity and homogeneity of variances is the Q-Q plot of the residuals and predicted values (Figure 16). Normality was again demonstrated, although minor lifting at the upper end is seen, it does not detract from the validity of the final model.

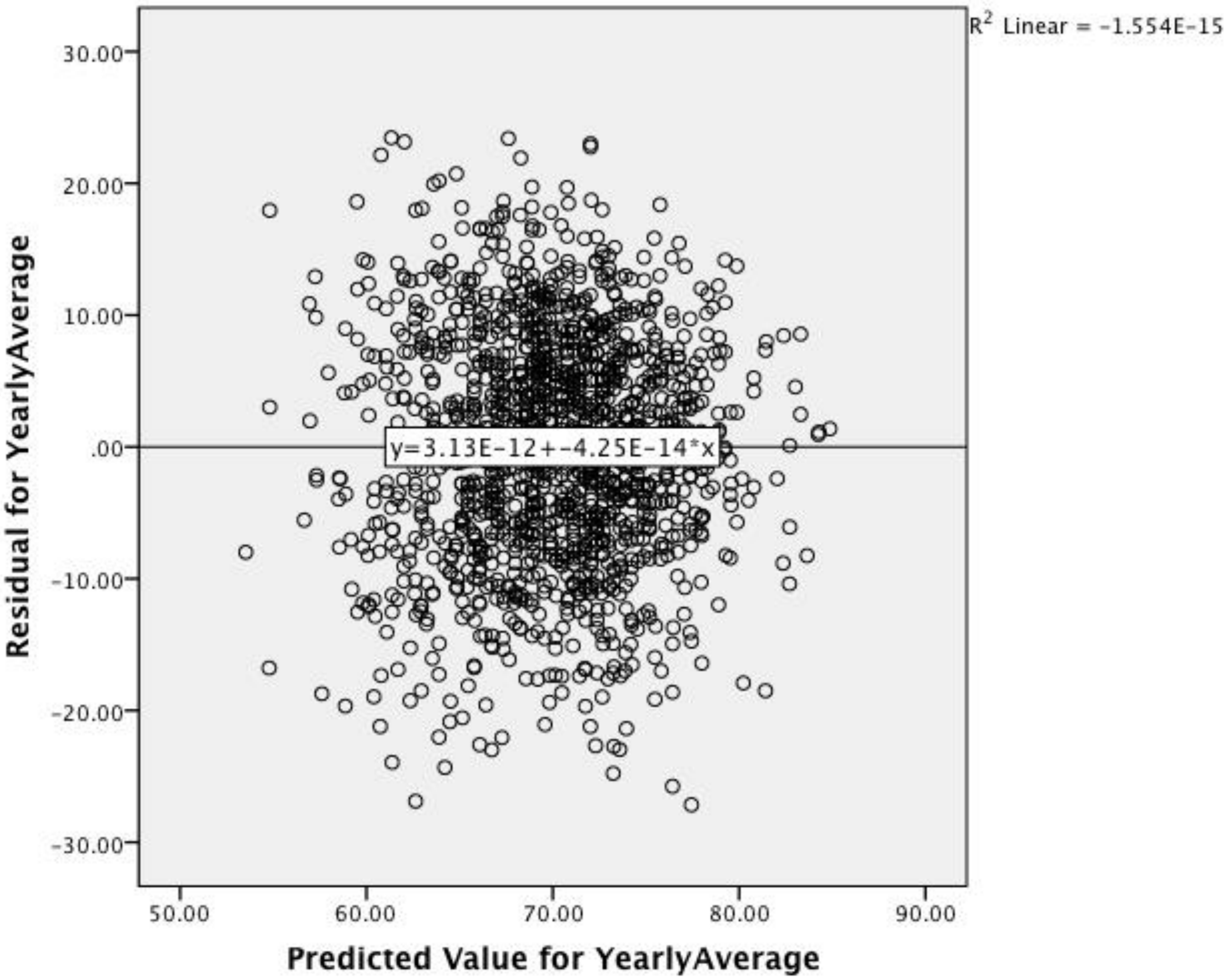


Figure 15: Scatterplot of Predicted Values and Residuals to test for Assumption of Normality

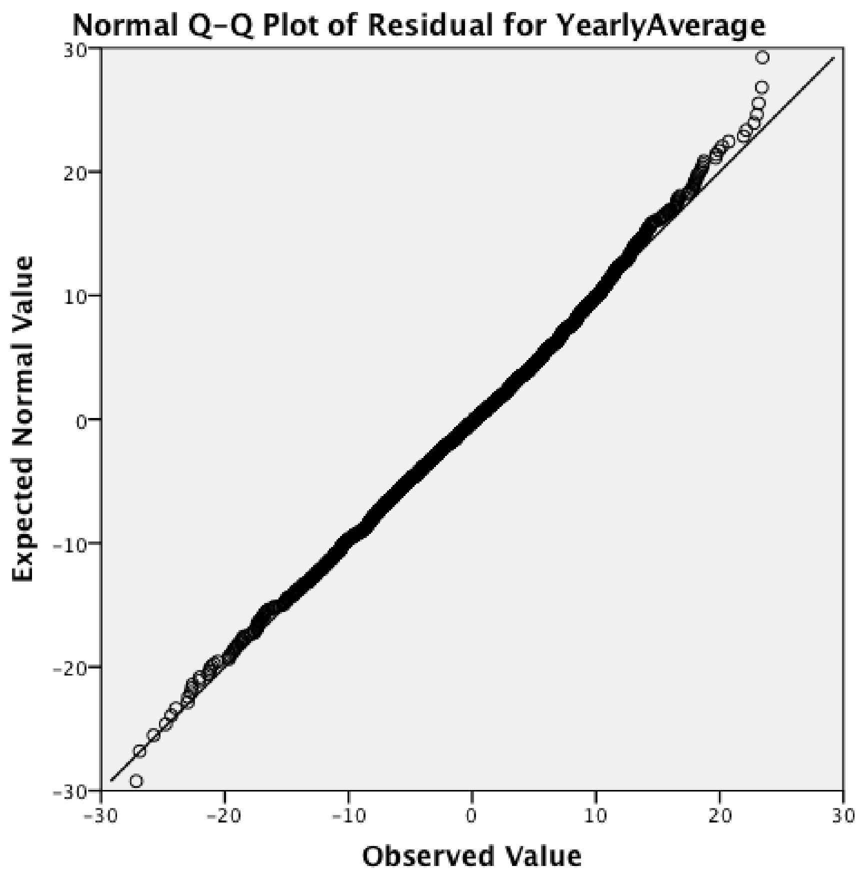


Figure 16: Q-Q plot of Predicted Values and Residuals to test for Assumption of Normality

Chapter Four Summary

Chapter four presented the results of the analyses performed that provided the opportunity to determine if statistically significant differences could be found on exam scores earned by equivalent students taking equivalent instruments (exams) when the POGIL intervention was utilized compared to a control group (didactic lecture only). Analyses included bivariate General Liner Models and a Pearson correlation performed on pairs of data (a single independent variable and the dependent variable) to determine the significance of each independent variable and potential for inclusion in the ANCOVA model. The final regression model built incorporated only those variables, and interactions between variables, that were significant – resulting in a model that examined the main effects of intervention, gender, declared major, and SAT scores explaining nearly 28% of the variability seen in the data set.

Once statistical significance on earned scores between populations was established, further analyses determined if a relationship existed between specific demographic data and the impact on the ability of the student to utilize and retain knowledge through the intervention. The demographic data examined were gender, ethnicity, declared majors in the STEM fields versus non-STEM fields, and the earned exam averages of students based on the SAT scores earned pre-admission. The demographics that showed positive statistical significance on earned scores were gender, declared major, and SAT scores. Changes were seen in the statistical significance observed on achieved scores pre and post intervention, sometimes rather large observed changes, when considering ethnicity, but no ANOVA results were found to be within the accepted limitation of $p < 0.05$ in this category.

Research question one investigated the effect of the intervention on exam scores after controlling for co-variables. The results of the analyses show the intervention was significant;

raising test scores 3.1% after implementation of the intervention. Research questions two through five investigated the effect of specific student characteristics on test scores. Gender also demonstrated a significant effect, with females scoring 1.9% higher than males. Declared major showed the second strongest effect, with students in a declared STEM major averaging 5.6% higher scores than the non-STEM major student did. SAT scores affected test scores the most, a 3.1% increase for every additional 100 points a student scored on the SATs. Ethnicity did not significantly explain any variability in the student class averages. Answering the final research question, the student characteristics that explained the variability seen were gender, declared major, and SAT scores. Chapter 5 will further discuss these findings and implications of the results as they compare to current research.

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CHAPTER 5: Discussion

Overview

The purpose of this longitudinal causal comparative/quasi-experimental study was to examine the quantitative effect of using a hybrid teaching methodology that included active learning strategies (POGIL activities) on student scores in a forensic science survey course. Our study also focused on student characteristics that may have affected the use of the active learning lesson, and therefore caused a variation in exam scores. In this study, the student characteristics focused on were gender, ethnicity, the student's declaration of a STEM major or non-STEM major, and the SAT scores submitted upon entrance to the University. As such, the present research has significantly extended the literature on authentic, active learning strategies by developing a systematic approach that is geared for forensic science and even science educators in general. Recognizing that student characteristics may also impact the use of the active learning lessons, this study aimed to assess both the relative impact of the course created POGIL activities, as well as determining if any of the student descriptors significantly impacted the variations seen in student class averages. Importantly, this study more broadly provides quantitative insights into how collegiate active learning strategies in large lecture formats may influence student learning.

Summary of Quantitative Results

This study utilized a causal comparative quasi-experimental design defined by Sage (2010) that attempted to determine relationships among variables, but does not allow for the manipulation of all of the variables involved, nor does it randomly place subjects into control and experimental groups. This section will present a brief summary of results, highlighting statistically significant findings that help explain the observed variability in student class averages.

The final sequential multiple regression model, explaining nearly 28% of the variation seen in student class averages, showed four of the variables to be statistically significant. All variables - intervention, gender, ethnicity, declared major, and SAT scores - were used in the initial univariate general linear model (GLM) based on significance levels ($p < 0.15$) established during bivariate pairing. A full factorial model was run which analyzed each main effect and all collinear interactions. Any main effects or interactions that showed p values greater than 0.05 were eliminated in sequential future custom GLM analyses. This guideline eliminated both the single variable of ethnicity and all interactions between variables. The final model provided evidence that the intervention, gender, declared major, and SAT scores were significantly responsible for explaining the variance seen in student class averages.

The use of the POGIL intervention in a hybrid methodology explained the third highest percent (2.9%) of the variation seen in the data, with the post-intervention students scoring 3.1% higher averages than the pre-intervention population. This statistically significant increase in student class averages mirrors only some studies (Lewis, 2008, Brown, S., 2010 and Vanags, 2013) while other published studies did not find statistical significance but demonstrated a higher level of student satisfaction with the active learning ideology compared to straight didactic lecture (Jin, 2011, Bailey, 2012, and Luxford, 2012). Most interesting is the statistically significant effect of a 3.1% increase mirroring the same effect found in 100-point differences for student SAT scores. The impact on students with lower SAT scores demonstrated to be much higher than those in higher SAT ranges [a 5.6% increase in the 700-1000 range compared to 3.3% increase in the 1100-1400 range]. The implications of this suggest students in the lower ranges, often found to be under-represented minorities (URM), have the potential for a larger impact through active learning.

This study refutes the notion that “the gender gap in STEM disciplines goes beyond limited representation of women – women earn lower exam grades and lower scores on standardized tests of conceptual mastery” (Miyake *et. al*, 2010, p. 1234), and supports the ideology that using active learning lessons in a group environment will be more beneficial to women than men. The post-intervention female population scored 1.9% higher averages than the male population, explaining an additional 1% of the observed student average variation. A consideration of the comparative pre-intervention student class averages also supports the recent trend seen in the gender gap in science education where “many of women’s historical disadvantages in education have not only disappeared in the United States and other industrialized countries, they have reversed (Buchmann, Diprete, & McDaniel, 2008, p. 337).

Acknowledging that STEM and non-STEM students develop science literacy in different ways, an examination of each student’s declared major allowed this study to further explore the use of active learning effects on those differentiated students. Students in this study with a STEM major outperformed the non-STEM major population by 5.6%, explaining an additional 6% of the variation. In previous studies, some educators found active learning enhanced the non-STEM student (Crossgrove and Curran, 2008) while others found non-STEM students were more engaged, but did not find the active learning as beneficial as lecture (Gill, 2011).

SAT scores explained the highest percent of the variation seen (18%), with students earning 3.1% higher averages for every 100 points higher SAT scores, extending the work of other researchers that demonstrated SAT scores accurately predicted success in STEM courses (Nelson, 2006; Rohr, 2012). This was the strongest explanation of variation but the least surprising data observed. Multiple studies have unquestionably demonstrated students earning higher SAT scores are better equipped to perform well in their studies, where one particular study created a modified scoring to include SAT scores as the quantified a predictor for student success (Bunce & Hutchinson, 1993).

"It is suggested that group work promoted status differences, with students in a particular majority viewing minority students as less competent thus begetting rejection and exclusion" (Cohen, 1991, p. 101). Our study and others (Freeman 2008; Khan, 2012) examined the need to consider how the small cooperative groups for active learning are created and function. The premise that a heterogeneously grouped ethnic mix will produce the greatest effect was not supported by our research study, as ethnicity was not deemed statistically significant. Although changes were seen in the initial student class averages within ethnic groups, SAT scores potentially hid the variations in ethnicity from pre- to-post intervention; this may be partially explained by the SAT exam being an ethnically biased exam (Freedle, 2003). Removing SAT scores does expose ethnicity as statistically significant, but that GLM (Appendix G) is not as valid as the ANCOVA analysis including SAT scores. In the alternative model, African American/Black and Hispanic students were the most significantly affected, two ethnic groups often listed as under-represented minorities.

Discussion

As indicated above in the summary of the quantitative results, this study revealed four of the examined variables to be statistically significant. The discussion of the findings will be organized and presented in the following order: (a) the POGIL intervention, (b) gender differences, (c) the declared major of the student, and (d) SAT scores. Ethnicity as a potentially significant descriptor when SAT is removed will also be discussed.

POGIL intervention

The increase seen in our study is almost three times higher than the study performed by Lewis and Lewis (2008) using PLGI methods, yet this type of increase in exam scores was only reported sporadically until 2010 when more POGIL adaptations found their way into diverse educational settings.

> Active learning methods are becoming more prevalent in science education as the verifiable evidence of their success becomes apparent to more educators…with student performance on lecture exams, the comprehensive final, and the course overall being significantly higher in the POGIL sections than in the final lecture-only offering of the same course. (Brown, 2010, p. 154-155)

Nadolski et al. (2005) studied the effects of process worksheets with law students and found that the availability of a process worksheet had positive effects on learning task performance and, although their research recorded that learners receiving guidance through process worksheets outperformed learners left to discover the appropriate procedures themselves, detailed analysis was not performed. In the study performed by Lewis and Lewis (2008), after controlling for SAT average, the PLTL reform was expected to result, on average, in scores 1.19 points higher, which would allow the researchers to determine the reform to be effective. “Though the improvement may seem small, for a reform that reduces lecture time and contains an explicit focus on skills such as communication, management, and teamwork, seemingly unrelated to content, an actual increase in student performance on an externally constructed relatively traditional content exam is noteworthy (Lewis and Lewis, 2008, 802).

In a case study in a large enrollment class (Bailey *et al*., 2012), student-centered active learning approaches were demonstrated to be valid and to have a large number of advantages with regard to student learning, but no statistical analysis was provided. Students appeared to perform slightly better on exam and quiz questions when the guided inquiry modules were applied in Jin & Bierma's study (2011), however, the difference seen in student scores was not found to be statistically significant. Brown (2010) found that students who participated in the student-centered learning environment using guided inquiry exercises outperformed those who did not on conventional multiple-choice examinations. While the difference between groups was again not considered overwhelming, (2.8%) it was statistically significant.

The varied results reviewed, quantitative or qualitative, suggest that POGILs or variations of POGIL produce better long-term retention of information. The POGIL activity may produce what appear to be minimal advances in achievement, but it should not be discounted that "the activities enabled the facilitator to identify prior knowledge that interferes with the acquisition of new knowledge. Traditional lecture had not previously allowed these ideas to surface, nor addressed them" (Luxford, Crowder, & Bretz, 2012, p. 213). A well designed, scripted POGIL activity provides the information needed, asks the right questions to guide students through the learning cycle, and helps students develop process and learning skills that can aid in retention of knowledge.

In this study the utilized POGIL activities were blended with traditional lecture to create a course/instructor specific hybrid. The ability for instruction to be hybridized positively impacts the future use of active learning lessons by increasing the potential for instructors to be willing to incorporate such modifications.

> Active learning, student-centered pedagogical approaches put the focus on the learner and what the learner does. However, active learning does not just happen; it occurs in the classroom when the teacher creates a learning environment that makes it more likely to occur…Implementing these newer approaches to teaching requires the teacher to become a learner, because if these approaches are not implemented in a well thought out way, their outcomes will not meet expectations (Michael, 2006, p. 164).

Gender Differences

Decades of research studied the ‘gender gap’ found in science education. Without additional motivation given to the female population, it was suggested that the gender gap would continue and widen, and one way to actively encourage young women to participate and develop higher cognitive skills was through “constructive inclusion learning environments” (Alexakos & Antoine, 2003, p. 33). Our study supported the idea that active learning groups may improve female learning more than their male counterparts, although both males and females saw student class average improvements. These results are similar to a study done by Nelson & Leganza (2006) where the female students performed better in a course normally found to be male dominated. The basic sciences remain a primarily a male-dominated environment, but forensic science is unique among the sciences and has seen a larger number of women entering the ranks, evidenced by this study’s population differences [2/3 female population].

The reasons for gender differences in education are still considered unknown. In a study performed by Speth and Brown (1990), complex interrelations were found to exist between gender, learning approaches and other aspects of the learning environment, and Wyller & Wyller

(2002) identified different educational environments which could trigger gender differences in unpredictable ways. Spelke (2005, p. 953) summarizes the patterns of possible observed cognitive differences: "Girls and women tend to excel on tests of verbal fluency, arithmetic calculation, and memory for the spatial locations of objects. Boys and men tend to excel on tests of verbal analogies, mathematical word problems, and memory for the geometric configuration of an environment…" Spelke continues to explain that compared to larger, more reliable sex differences in measures of motor behavior, sexuality, and aggressions, differences in cognition are small, and it can be concluded that no differences between the abilities of females and males to learn math and science should be seen. (p. 953-954)

Spelke's study seems to be supported by our study, as observed student class averages of pre-intervention females and males were equal. Both genders saw increases in student class averages post-intervention, yet the improvements gained by females surpassed those seen in males. When examining the probable reasons women perform better on assessments of knowledge gathered during active learning activities, Wyller & Wyller's research (2002) found that the female students were more apt to identify the objectives of the lecture and place import on lessons that enabled them to facilitate their own learning when compared to their male counterparts. Neither sex would have difficulty contributing in the small group environment, but the female students were more likely to trust and accept information gathered from peers as valuable and applicable. The men in class were more likely to focus on what was necessary to get through an exam but performed poorly when compared to the women in the same class (p. 504).

Although our study is able to add to the statistic research base that a gender gap may exist when utilizing different educational methodologies, as a whole "we have much to learn about the nature, cause, and consequences of the changing gender gaps in education across the life course. This rapidly shifting terrain of gender inequalities raises important questions" (Buchmann *et al*, 2008, p. 337). Perhaps one of the most important aspects of gender issues in science education is the need to recognize not a gender gap, but that gender matters, and that "science is not a value-neutral subject" (Hussenius, 2014, p. 259).

Difference in Declared Major

Research performed by MacCann et al. (2009) supported the results of our study, demonstrating the possibility of inherent characteristics more likely to be present among students with a STEM major than non-STEM major affecting the testing ability of the student. Characteristics such as being careful, disciplined and self-controlled would be attributed to STEM major students rather than negative personality connotations more often seen in non-STEM students: low impulse control, direct expression of needs, difficulties with setting and managing performance-related tasks (MacCann *et al*, 2009).

Based on the above definition of a STEM student, it is not surprising this research supports the current theory that active learning enhances both science learning and the retaining of knowledge indicated by the average STEM student on assessments. The characteristics used to describe the STEM student would be those often found in the manager of the small POGIL group, and a mixing of STEM and non-STEM students within a group was presumed to be advantageous for everyone, but could possibly impact the non-STEM students more. Although both STEM and nonSTEM students saw increases in their student class averages, the STEM students retained the advantage of active learning methodology, so if science literacy was improved in non-STEM majors, the improvement was not enough to offer a greater advantage to those students compared to their STEM counterparts.

All types of students performed better post-intervention, and it is believed that due to the less rigid active learner environment, fear of offering an incorrect answer in the small group is considered minimized, and dialogue between STEM and non-STEM students aided in retention for students finding little benefit in didactic lecture. “Students are more likely to honestly express their ideas – both scientifically valid conceptions and misconceptions – in a peer group where they have no fear of looking stupid in front of a teacher who will be issuing grades” (Cracolice & Deming, 2001, p. 22). The improvement seen in both populations mirrored results found by The Learning Communities for STEM Academic Achievement (LCSAA) project, which suggests “students’ motivation and attitudes concerning science and mathematics are enhanced in classes that adopt learning communities’ educational approach” (Freeman, Alston, & Winborne, 2008, p. 236).

SAT scores

This study sought to identify factors that would cause student class average variations, focusing on the introduction of an active learning methodology intervention perceived to play the most important role in student class average variation. Not surprisingly, the strongest statistical significance was found in SAT scores, supported by Cohen & Loren’s 1995 study - “the more relevant a status characteristic is, the more power it has to affect the prestige and power order of the small group knowledge attainment and retention…where academic status characteristics are the most powerful of all status characteristics because of their obvious relevance to the classroom activities” (p. 117).

Most SAT ranges saw increases in our study, the exception being the negative effect on students in the 1500 range, an average of 3.1% for each interval, but an indiscernible pattern was found among the increases seen within intervals of 100. Post intervention students consistently outperformed their pre-intervention counterpart within the same SAT range with the highest improved averages seen in students entering the university with SAT scores in the 900s. Slightly greater improvements were seen in SAT scores in the 700 to 1000 ranges, and then the size of the student class average increases began to decrease with the lowest improved averages seen in the students with scores in the 1300s. After minimizing in the 1300s, greater improvements were again observed until the 1500 increment where negative effects were observed. Previous research suggested that the higher achieving students would gain more from an active learning approach, implying a linear effect of gradually increasing student class average improvements, but our study did not support this ideal:

> Cooperative learning is widely recommended as a method of creating equity in heterogeneous classrooms. However, small groups will also develop status orders based on perceived differences in academic status: high status students will interact more frequently than low status students will. Moreover, these differences in interaction can lead to differences in learning outcomes – that is, those who talk more, learn more (Cohen & Lotan, 1995, p. 100).

Although academic achievement, as evaluated on the SAT, is used as a predictor for both success in specific courses and retention of students in progressively more difficult courses, research that could help explain the largest student class average increase seen in the 700 and 900 intervals, and the smallest in the 1300, may be found in the ethnic differences hidden within the SAT scores. Active learning environments, such as POGIL, generate engagement and peer-to-peer interactions that offer an increased benefit to under-represented minorities (URM), leading this study back to the questionable significance of ethnicity (Lopez *et al*., 2013)

Ethnicity

This study did not find ethnicity remained statistically significant as the final GLM model was created ($p = 0.0586$), although previous studies have been completed that have identified ethnicity as a top contender for affecting the retention of information through an active learning group. “Heterogeneity and diversity are proven factors that have positive effects on outcomes of small group learning activities…when it comes to diverse student bodies, problem based learning is an effective method to enhance cross ethnic socialization, resulting in improved interpersonal dynamics and effective learning amongst students” (Khan & Sobani, 2012, p. 124).

All ethnic groups saw an increase pre-intervention to post-intervention and the increases were varied, with the highest increases seen in the African American and Hispanic populations and the lowest in the Asian populations, supporting Freeman et al.’s (2008) research, which demonstrated “a growing amount of scientific evidence suggests that learning communities enhance engagement and retention, particularly for African American students (p. 238). Having ethnicity in our study fall below the statistically significant level could be explained by the ambiguous effects the multitude of student characteristics working together can have: “The origins of alternative conceptions lie in students’ diverse personal experiences, which include observation, perception, culture, language, prior teachers’ explanations, and prior instructional materials…all of this prior knowledge interacts with whatever is presented in formal instruction, resulting in a wide variety of unintended learning outcomes by students (Cakir, 2008, p. 203).

Conclusions

POGIL pedagogy brings together several current best practices in science teaching that can be expanded into areas of study currently not utilizing active learning methodology. The hybrid pedagogy seen in this study epitomizes the need for incorporating more active learning, as described in the 2012 President's Council of Advisors on Science and Technology report (PCAST). PCAST indicates "economic forecasts pointing to a need for producing, over the next decade, approximately 1 million more college graduates in STEM fields than expected under current assumptions." Statistically, fewer than 40% of students entering a STEM field complete the degree necessary to enter the selected field successfully (PCAST, 2012).

> High performing students frequently cite uninspiring introductory courses as a factor in their choice to switch majors…Learning theory, empirical evidence about how people learn, and assessment of outcomes in STEM classrooms all point to a need to improve teaching methods to enhance learning and student persistence. Classroom approaches that engage students in "active learning" improve retention of information and critical thinking skills, compared with a sole reliance on lecturing (PCAST, 2012)

This hybrid study demonstrated the positive impact seen when active learning is applied to an introductory course.

During the writing of each active learning lesson, the author acknowledged every POGIL lesson needs to be designed so that it engages students by:

- developing a cooperative learning environment where students discuss their ideas, confront their lack of understanding, and negotiate meaning as concepts are discovered and personal mental models are being formed

• incorporating the structured use of many types of teaching models

• demanding consistent use of higher order thinking skills

• integrating process skills into the acquisition of content

• differentiating instruction from the traditional lecture method to an active, student-centered approach, which allows for differentiation of content, product and process

• allowing teachers to facilitate content mastery as opposed to content coverage

Although this study focused on the use of the POGIL project and lessons created using the POGIL guidelines, the primary importance of incorporating any type of active learning should not be understated. Using one or more methods from a multitude of teaching techniques and approaches, teachers can effectively target ranges of different learning styles while they challenge their students to think and learn in new ways, “so as an educator prepares to create an active learning classroom, it is important to use a variety of teaching delivery techniques” (Auster & Wiley, 2006, p. 340). An incorporation of active learning could include the PLGI found in Lewis and Lewis’ (2008), the hybrid POGIL and online lecture found in Baum (2013), or another type of hybrid model as we have demonstrated in this study. All of these were “courses that considered alternative conceptions of knowledge and were more likely to be associated with meaningful learning outcomes” (Kember, 2009, p. 2-3).

Previous studies indicate that the replacement of one lecture a week with a reform-oriented (active) teaching intervention may serve as an appropriate testing ground for the feasibility and effectiveness of the intervention (Lewis & Lewis, 2005). Often instructors deliberately hybridized their teaching methods, as we did, using different pedagogies with the intent of maximizing certain elements felt to most beneficial to the classroom setting. With the large selection of active learning models that can be brought into the classroom, the argument should hopefully veer away from an attutude of dissent to change due to lack of available material to one more accepting of incorporating change in the classroom, even if required materials are not readily available. "It is our responsibility as educators to work toward developing students who are life-long learners and who are intrinsically motivated in their studies. Educators want the learning experiences that are created for students to be rewarding in and of themselves and not just because they provide high grades or curriculum requirements" (Freeman, Alston, & Winborne, 2008, p. 238).

Our findings document the potential for improvement that can be found through the incorporation of newer methodologies alongside the older, well-practiced didactic lecture. Active learning pedagogies are becoming more common, and their inclusion will continue as teachers and learners become more familiar with these approaches. The assumption should not be made that immediate success will be seen. The inclusion requires the use of active learning materials that have been proven useful, so finding those activities, or designing them, can be difficult. "One barrier [to using active learning] is developing effective materials that can require significant effort. However, once materials are developed, it can be relatively easy for other faculty to adopt and adapt them" (Kussmaul & Wenzel, 2012, p. 12).

An important aspect of active learning, however, is that active learning methodologies are not a panacea for "repairing" a perceived deficit in science education. Active learning lessons are tools, as is didactic lecture, and when used appropriately, <u>both</u> tools can be useful tools. The overall effect of the chosen instrument for teaching depends on particular student contexts and characteristics – educating and learning are both intensely personal, and educators need to select educational methodologies that fit their personalities just as students need to consider the method which they learn best by. Introducing active learning methodology requires more than just the lessons; considerations must be given to how groups will be formed, and how much ‘tinkering’ the educator will do when forming groups for the first time.

When incorporating an active learning lesson, with small groups in mind, the grouping of students based on student characteristics that are known- SAT scores, declared major, and gender – should be considered to heterogeneously mix the students into groups. Students purported to do well in the active environment are more likely to raise the efforts of the majority of the students working in the same group, raising all student scores in a synergistic effect.

> An increase in effort may equate to an increase in yearly exams. Research from education, psychology, neuroscience, and related disciplines shows that motivation and learning are enhanced when learners: receive prompt, regular feedback; work in teams; combine and connect content; process multiple representations; create or construct their own understanding; and reflect on their own processes and progress.
>
> (Kussmaul & Wenzel, 2012, p. 7)

Implications

The findings from this study, a 3.1% increase in student averages due to intervention, support the perception that an introductory science course can be enhanced with course specific, instructor designed, active learning lessons modeled after the POGIL Project. The quantitative data and statistical analysis employed in this study clearly demonstrates the increase in student assessment scores that may be seen with the blending of a hybrid didactic lecture and an active learning environment. Introducing an alternate methodology, however, does not necessarily mean following a proscribed curriculum within a rigid set of guidelines. Instructors interested in altering their teaching style can choose to implement changes within a wide range of alternative methodologies and still see improvements in the learning their students are doing. This study shows that a deviation from previously suggested models for the incorporation of active learning lessons can improve the performance of students if the educator is willing to investigate how to write course-specific active learning lessons and implement them in a manner that enables students of varied learning styles to be engaged and successful.

Educators in the collegiate levels have viable options to incorporate into the curriculum, enabling them to develop a more engaging learning experience for small class sizes and large lecture halls alike. The importance of inquiry in science education is not to imply that it is the only approach to science teaching. “Inquiry into authentic questions generated from student experiences is the central strategy for teaching science…it refers to the activities of students in which they develop knowledge of understanding of scientific ideas as an understanding of how scientists study the natural world” (Anderson, 2002, p. 2-3). If inquiry isn’t the choice the educator chooses to incorporate, an alternative learning methodology should be chosen that the educator can successfully implement to add to the didactic lecture the professor is already comfortable with. Most important is the need for educators to closely examine how they are currently teaching their classes and ask themselves if they are offering the best learning experience possible for today’s varied students.

The students themselves were also examined during our study, as both individuals and a larger population. A student population the size of the lecture hall studied here has a wide diversity of student interest, background and abilities, and not all learning styles are conducive to being successful in an active learning environment, just as they are not conducive to being successful in an exclusively didactic lecture environment. These findings, as well as previous research, point to critical student characteristics to take into consideration when looking to incorporate an alternative teaching method. Our study identified female students, within a lower range SAT score and STEM declared majors, could achieve the most from an active learning inclusive lesson. As SAT scores are inherently tied to ethnicity, the study potentially extends the positive impact due to active learning to under-represented minorities.

All characteristics were impacted in some way by the intervention that was introduced, and our findings support the previous research that encourages educators to take into consideration students with diverse previous educational environments. Gender, ethnicity, declared major of the student, and SAT scores should each be considered if the instructor is inclined to build a heterogeneous group that may maximize personalities and learning styles that will symbiotically enhance each other and maximize improved learning and retention. Forming such groups, however, could mean meeting students beforehand and having a much deeper understanding of students and how they learn if the population of students does not have all variables listed, enabling a true random assignment to be performed.

Recommendations for Future Research

The findings from this research study deepens our understanding of the application of active learning methodologies, such as the POGIL method, to a wider scientific base, specifically forensic science and in settings with a modified instructor-pupil ratio of 1:200. The results are valuable as they contribute both to general application of alternative instructor styles in science, as well as providing examples of course-created POGIL activities in a forensic science survey course that have demonstrated positive quantitative improvements in student scores.

Further development of course-created activities in an introductory course, as well as higher levels of forensic science, should be explored. It should be emphasized that undertaking the creation of course-specific materials requires creativity and the willingness to search for available model preparations that will enhance the active learning lesson the most. The writers of future activities should seek a conference or mentor to guide the writing of the activities to maximize the research on the learning cycle being applied by the POGIL project.

Investigation into the student parameters that affect the active learning environment should be explored further to enable the instructor to maximize the knowledge of the student learner. This knowledge is needed to successfully implement the change from didactic lecture to alternative teaching methodologies should an educator choose to deliberately place students into small groups based on the student characteristics available to the professor before the class starts (gender, ethnicity, declared majors, and SAT scores). A primary avenue of exploration may include trying to identify and understand the improvement differences seen between the genders. Understanding why this observed difference occurred may help identify an enhanced blending of teaching methodologies more attuned to gender specific learning styles.

As identified in previous research, the STEM student has a higher science literacy which can impact the small group dynamic. Exploring the possibility of heterogeneously arranging the POGIL groups by declared major to maximize valuable personality and academic styles students bring with them could uncover positive data. Data supporting the need to deliberately group students before class begins rather than allowing student created groups based on proximity. Further explorations into why the students within varied SAT score ranges behaved the way they did would create a more defined understanding of how academic achievement can be impacted by varied learning methodologies. Research to date has supported the findings seen here that higher SAT scores earned increased student class averages overall, but the fluctuations between SAT groups remains unexplained. Of equal importance is the link between SAT scores and ethnicity, and the impact active learning has on under-represented minorities needs to be further explored.

Limitations

Although this study has several strengths in design and analysis, there are key limitations that should be noted. Perhaps the most significant limitation is the reliance on multiple-choice exams as indicators of student achievement, exams that could not be completely demonstrated to be statistically equal from year to year. While the exams are limited measures of student knowledge, they are directly relevant for considerations of whether students will go on in science, both in the study setting and in many large lecture courses (Zoller, 1993). As many controls as possible were in put into place, with the same professor writing all of the exams using the same language and style of questioning. The same material was being tested, with the same level of detail of retained knowledge being explored by the questions. Item analysis and item difficulty data provided by OIRA suggests an equivalency from year to year, but statistical analysis that can support this was not available. Even examinations with identical questions, organized in a varied order to be given on the exact date and the exact time to reduce the possibility of cheating cannot be purported to be equivalent (Pettit, 1986).

The size of this study (N = 1436) also proves to be quantitatively impacted, a sample size of 200-300 is often suggested (Tavakol & Dennick, 2011), and larger sample sizes are recommended to be ‘split in halves’. However, the splitting of data more easily skews results to imply a larger correlation than actually exists. The entire data set was incorporated into the univariate and GLM models, with the understanding that the larger data set would reduce the Cronbach alpha of the final GLM model.

Another limitation of this study is that the interactive materials used do not conform exactly to the POGIL project suggested style. In addition, the actual POGIL implementation in this study is not necessarily the way others might implement the POGIL, as seen in the previous explanation (Chapter 3) of normal POGIL procedures. The research performed here is based on a hybrid model exclusively developed for the course being taught, and may not be the best hybrid choice for other science courses in its entirety. Deliberate consideration of educator strengths, classroom size, and heterogeneity of students should be given when developing the hybrid model for any science course considering a hybrid model.

Appendix A

Sample Schedule

POGIL Activities (alphabetical order)

- Arson and Explosives
- Blood Typing
- Crime Scene
- DNA Analysis
- Fingerprints
- Handwriting and Voice Analysis
- Historic Development
- Human Forensic Evidence
- Maggots to Murder
- Medicinal Chemistry
- Science v. Pseudoscience
- Skulls, Hips, and Femurs
- Soil, Residue and Paint
- Spectroscopy and Chromatography

CHEMISTRY 113
Approximate Schedule

Week	Topic	Text[1]	POGIL	Lab
Tues., Jan. 17 Thurs., Jan. 19	Introduction to Forensic Science Evidence and the Law in Forensic Science	RS Chapter 1 RS Chapter 1	Historic Development of Forensic Science	None
Tues., Jan. 24 Thurs., Jan. 26	The Crime Scene and Physical Evidence I The Crime Scene and Physical Evidence II	RS Chapter 2 RS Chapter 3	Crime Scene and Physical Evidence	Safety Lab
Tues., Jan. 31 Thurs., Feb. 2	Science vs. Pseudo-Science Microscopy	RS Chapter 3 JTS Chapt. 4	Science v. Pseudo-Science	Statistical Lab
Tues., Feb. **7** **Thurs., Feb. 9**	Biochemical Forensic Analysis I **EXAM I**	JTS Chapt. 6	Blood Typing	Blood Spatter
Tues., Feb. 14 Thurs., Feb. 16	Biochemical Forensic Analysis II Biochemical Forensic Analysis I	JTS Chapt. 6 JTS Chapt. 5	DNA Analysis	DNA Extraction Lab
Tues., Feb. 21 Thurs., Feb. 23	Biochemical Forensic Analysis I External Anatomical Evidence	JTS Chapt. 5 JTS Chapt. 7	Fingerprints	Fingerprint Lab
Tues., Feb. 2 Thurs., Mar. 1	External Anatomical Evidence Internal Anatomical Evidence	JTS Chapt. 7 JTS Chapt. 8	Human Forensic Evidence	Anthropometry Lab

Tues., Mar. 6 **Thurs., Mar. 8**	Forensic Anthropology **EXAM II**	JTS Chapt. 9	Skulls, Hips and Femurs	
Tues., Mar. 13 Thurs., Mar. 15	Spring vacation – No Classes (Mar. 110 - 19)			
Tues., Mar. 20 Thurs., Mar. 22	Forensic Ecology Forensic Ecology	JTS Chapt. 10	From Maggots to Murder	Chromat.
Tues., Mar. 27 Thurs., Mar. 29	Overview of Forensic Chemistry and Forensic Spectroscopy Medicinal Chemistry	RS Chapter 5/6	Spectroscopy and Chromatography	Organic ID
Tues., Apr. 3 Thurs., Apr. 5	Medicinal Chemistry Mineralogical, Soil, Residue and Paint	 RS Chapter 4	Medicinal Chemistry	Density and Refractive Index Lab
Tues., Apr. 10 **Thurs., Apr. 12**	Explosives and Arson **EXAM III**	JTS Chapt. 14	Arson and Explosives	**Lab Rotations:** (a) Crime Scene (ii) Dirty Money Lab (iii) Hair/Fiber /Microscopy
Tues., Apr. 17 Thurs., Apr. 19	Overview of Physical Measurements Firearms and Ballistics	JTS Chapt. 4 JTS Chapt. 16	Soil, Residue and Paint	**Lab Rotations:** (a) Crime Scene (ii) Dirty Money Lab (iii) Hair/Fiber /Microscopy
Tues., Apr. 24	Forensic Document, Palaography, Audio, Photographic, and Video Analysis	JTS Chapter 17	Handwriting / Voiceprint Analysis	**Lab Rotations:** (a) Crime Scene (ii) Dirty Money Lab

Thurs., Apr. 26	Forensic Psychology			(iii) Hair/Fiber/Microscopy
Tues., May 1	Review for Final			None

Final Exam: **Thu, May 3rd, 5:15 pm - 7:15 pm**

Arson and Explosives

What makes a chemical compound an explosive?
How do we know if a fire has been set deliberately?

Why?

An **explosive material**, also called an **explosive**, is a reactive substance that contains a great amount of potential energy that can produce an explosion if released suddenly, usually accompanied by the production of light, heat, sound, and pressure.

Arson is the crime of intentionally and maliciously setting fire to buildings, wild land areas, vehicles or other property with the intent to cause damage. It may be distinguished from other causes such as spontaneous combustion and natural wildfires.

Learning Outcome

- Students will be able to identify the difference between an oxidation and reduction reaction
- Students will be able to identify a basic combustion reaction
- Students will be able to identify the components needed for a fire to burn
- Students will be able to identify the 'signature' of an arson fire

New Concepts

There are specific requirements for a fire to begin and to continue burning

There are some recognizable characteristics of fire that can imply an arson

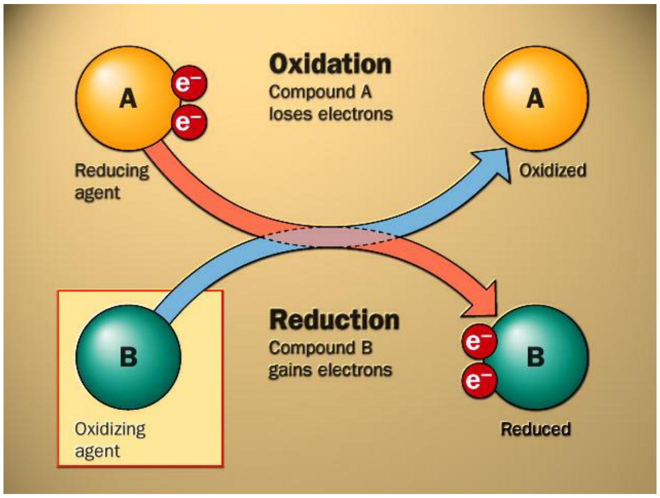
Prerequisites

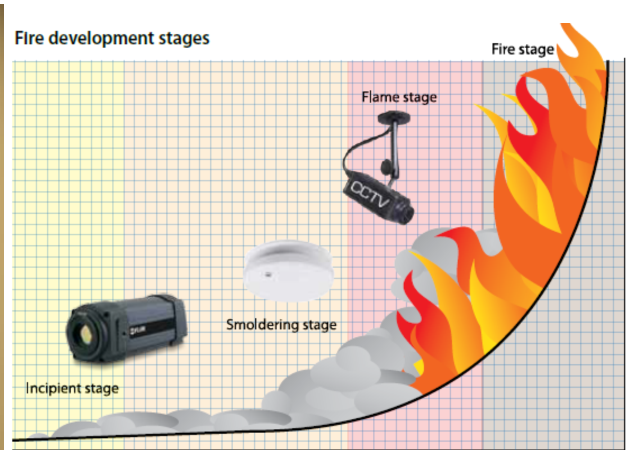
- none

Reading Assignment

Saferstein, 8th edition, pg.

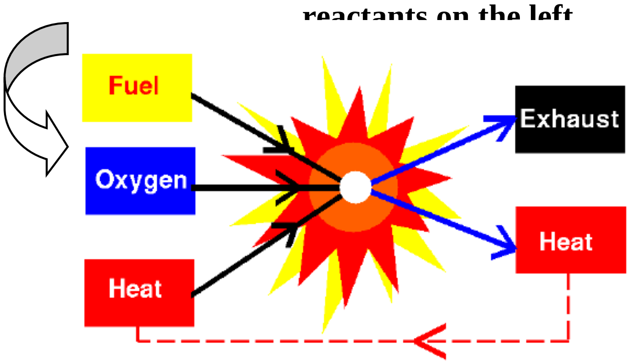
Model 1 : Oxidation Reactions; Combustion

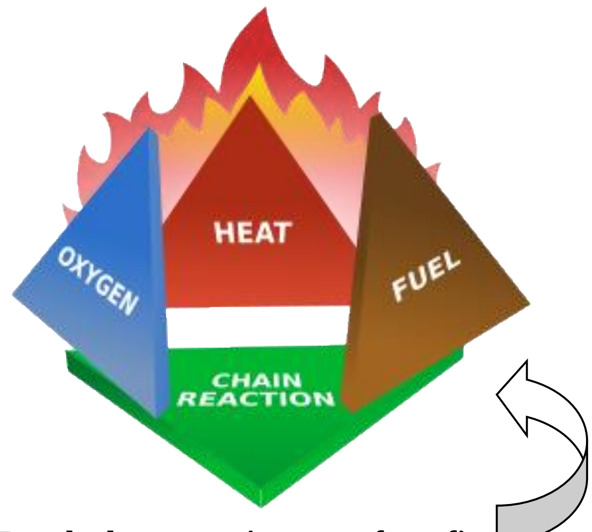




Combustion Reaction:

reactants on the left





Fire Tetrahedron: requirements for a fire

*Use lecture notes and quick internet searches to clarify the definitions not clear from the diagrams

Questions

1. What is an oxidation reaction?

2. What is a reduction reaction?

3. What is a combustion reaction?

4. What is fire and what are the roles of the components in the fire tetrahedron?

5. How can you suppress a fire?

6. What are the classes of fire based on possible fuel sources? *Lecture or Internet search

7. What are the stages of fire?

Model 2 : Arson Investigations

Goto webpage:

http://crimeandclues.com/2013/01/26/arson-investigation/

Figure 6. View to W wall of cell 3 showing a large, clean-burn "V-pattern"

Figure 7. View of N wall of cell 3 through the doorway. Note the area of clean-burn.

Figure 8. View to SW in cell 3 showing damage to the bed's east side near the door

Figure 9. View to SE in cell 3. Note the absence of clean-burn near the origin

Questions

8. What type of information is part of a fire investigation? What is meant by arson and what are some of the telltale clues to intentional fires?

9. How is arson evidence collected and protected when taking into custody? *Think back to Chapter 2

10. How might a suspect be detected during an arson investigation? What evidence would you need to get a warrant?

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http://www.flir.com/uploadedImages/CS_EMEA/Application_Stories/Automation/Images/Fire_development_stages.png, viewed 3/2010
http://upload.wikimedia.org/wikipedia/commons/thumb/9/99/Fire_tetrahedron.svg/2000px-Fire_tetrahedron.svg.png, viewed 3/2010

Webpages:
http://crimeandclues.com/2013/01/26/arson-investigation/

Blood Typing

How is a human sample analyzed to determine the blood type?

Why?

Blood is a complex mixture of cells, enzymes, proteins, and inorganic substances. Understanding the different components of blood allows a scientist to use the components in simple and efficient tests, whether the tests are done one site at the crime scene, or more complex tests are performed in a crime laboratory.

Learning Outcome

- Students will be able to identify the components found in blood.
- Students will be able to distinguish between antigens and antibodies, and the uses of these two components in blood typing.
- Students will be able to apply genetic inheritance of blood typing using Punnet squares.

New Concepts

Blood is primarily made up of a fluid portion, called plasma, and three types of cells – erythrocytes, leukocytes, and platelets.

Proteins found in blood are made from amino acids linked together through a peptide bond.

Serology, the study of the proteins found in blood, used in forensics will focus on the antigen / antibody protein connection to determine blood typing.

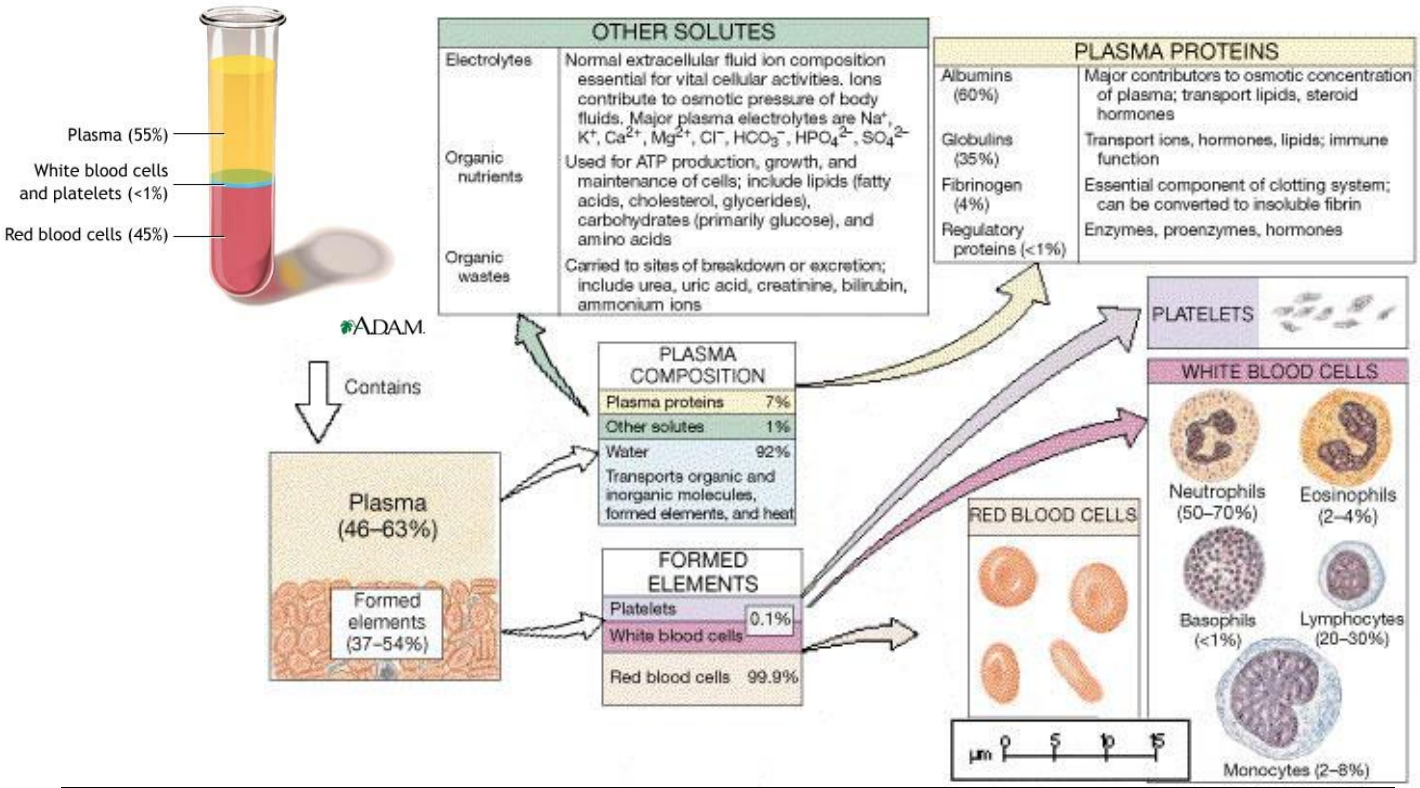
Prerequisites

- Protein synthesis, DNA, chromosomes, genes, human reproduction

Reading Assignment

Saferstein, 8th edition, pg. 328-346

Model 1 : The Mixture Known as Blood



	Other common names used	Facts worth Knowing
Plasma		- a clear yellowish fluid that sits on top after solid particles have been spun out, can be milky in color after a fatty meal due to the fat molecules being suspended
Erythrocytes	- Red blood cells	- percentage of blood made up of red blood cells is commonly called the hematocrit - shaped like a shallow bowl, called a biconcave disc - has NO nucleus, extruded out upon maturity - can change shape, allowing it to squeeze through very small spaces - contains hemoglobin, the protein that carries oxygen - have antigens on their surface, a protein with a specific shape that determines the blood type of the person
Leukocytes	- White blood cells	- part of the immune system and fights infection
Thrombocytes	- Platelets	- help clot blood by spinning out fibrins that form a plug

Questions

1. What part of blood exists in the highest percentage? The lowest?

2. Which cell exists in a larger percentage in the blood?

   What is it's "job"?

   Based on what you know about this cell, how is it important as forensic evidence and why?

3. Which cells exist in smaller percentages in the blood?

   What is each of their "jobs"?

   Based on what you know about this cell, are they important as forensic evidence and why?

Exercises

1. What is the shape of the red blood cell? Why is its shape important?

2. What is a major difference between the red blood cell and white blood cell from a forensic scientist's viewpoint?

3. What are the four questions *identified in lecture* we should be able to answer concerning blood evidence found at a crime scene:

   a.

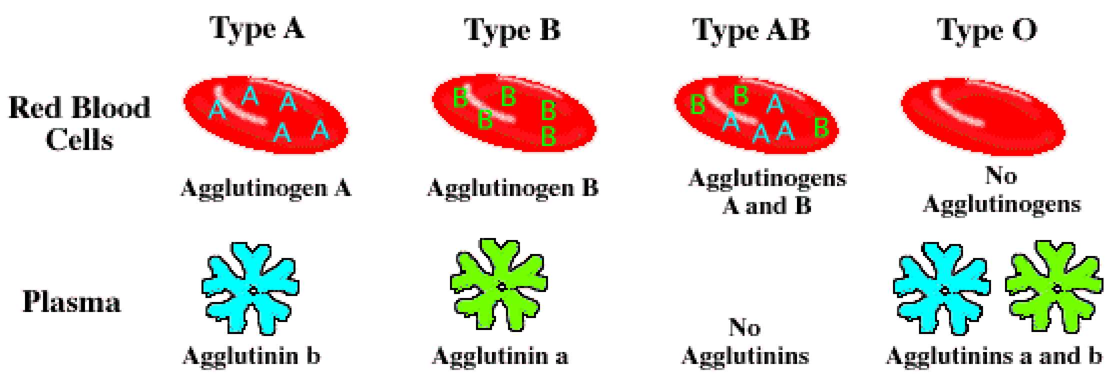
   b.

   c.

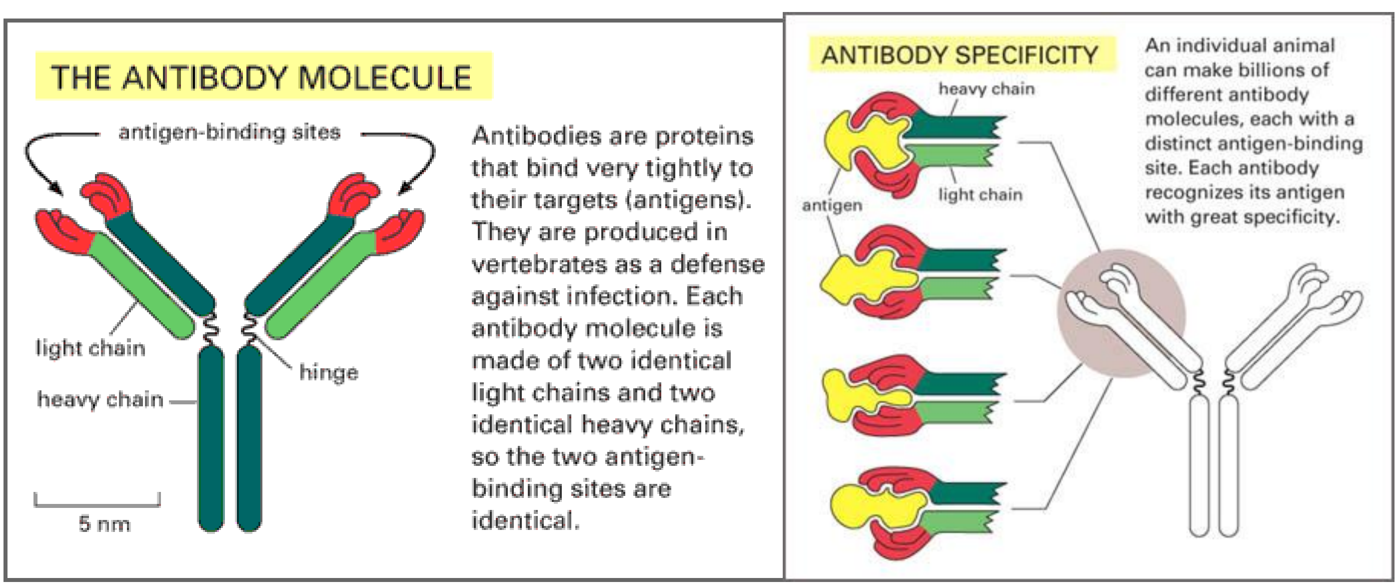
   d.

   *Looking back at the questions, what forensic test(s) do we use to answer each of the above questions? Fill the test in next to each question, listing the positive response expected…

Model 2 : Determination of Blood Type



- **Agglutinogens are proteins called <u>antigens</u> that exist on the red blood cells.**
- **Agglutinins are proteins called <u>antibodies</u> that exist in the plasma**
- **If a matching antigen and antibody come into contact they <u>agglutinate</u>, or clump together, to be removed**



Questions

1. Fill in the following data table concerning the antigens present on the red blood cell, the antibodies found in the plasma, and the blood type being described…

Blood Type	Antigens on RBC	Antibodies in Plasma
A		
B		
O		
AB		

2. How does blood typing affect blood donations/acceptors?

3. Below is a table with the results of a blood typing test. Identify the blood types based on the reaction with the antisera.

Sample	Result with anti-A	Result with anti-B	Blood Type
1	agglutination	no reaction	
2	no reaction	no reaction	
3	no reaction	agglutination	
4	agglutination	agglutination	

Exercises

4. Use Punnet Squares to determine the possible blood types of Charlie Chaplin's son, knowing that Chaplin is Type O and the mother is Type A…

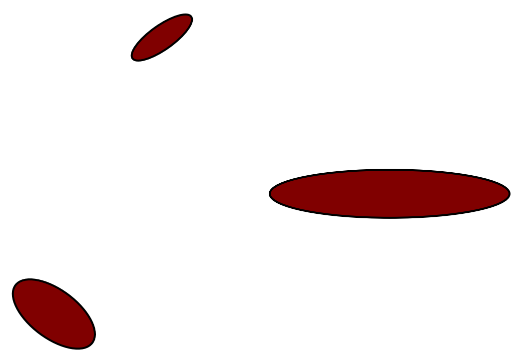
Model 3 : Blood Spatter Analysis

Will be provide together as mini lab in lecture to prepare for lab.

Using a ruler and protractor, analyze the given blood spray: (5 points)

Identify the point of origin from the spatter

Create a data table for each of the three drops that will allow you to graph the drops and determine the height above the ground



Go to webpage: http://lowdownblog.com/2011/07/26/how-blood-stain-pattern-analysis-works-infographic/

Questions

1. Describe each of the following bloodstains:

    a. passive:

    b. projected:

    a. transfer:

2. Describe what you would look for to determine the direction a blood drop was traveling? How do you use this analysis?

References:

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Crime Scene and Physical Evidence

What are the correct steps taken when a crime scene is approached, searched, and an investigation is begun?

Why?

One of the most vital components of crime scene investigation is the collection, preservation, and securing of evidence. If those three components are not carefully maintained the evidence cannot be used in a court of law – which is in fact the purpose of evidence!

Learning Outcome

- Students will be able to identify the steps taken during the beginning of a crime scene investigation, and all the way through the investigation itself.
- Students will be able to list the details of each the jobs assigned during a crime scene investigation, and apply those skills to a model..
- Students will be able to recognize the importance of the use of chain of custody and search warrants.

New Concepts

All the jobs combine during the crime scene investigation to produce evidence that can be used in a court of law – leader, photographer, note taker, sketcher, and evidence collector.

The chain of custody for evidence must start at the crime scene and continue throughout the investigation.

Different circumstances must be considered when searching for evidence outside of the crime scene, including the need for a warrant or determining if a warrantless search is necessitated.

Prerequisites

- Definition of forensics, Types of Analyses available in a crime lab

Reading Assignment

Saferstein, 8th edition, pg. 34-52

Model 1 : Introduction to How Crime Scene Investigation Works

Video Clip: http://investigation.discovery.com/tv-shows/cold-blood/videos/cold-blood-processing-crime-scenes.htm

At the Crime Scene : Scene Recognition	At the Crime Scene : Scene Documentation

When a CSI arrives at a crime scene, he doesn't just jump in and start recovering evidence. The goal of the scene recognition stage is to gain an understanding of what this particular investigation will entail and develop a systematic approach to finding and collecting evidence. At this point, the CSI is only using his eyes, ears, nose, some paper and a pen.
• define the **extent of the crime scene**. Is the scene the house and the immediate vicinity outside? Does it also include any cars in the driveway? Is there a blood trail down the street?
• **Securing the crime scene** -- and any other areas that might later turn out to be part of the crime scene -- is crucial. Securing the scene involves creating a physical barrier using crime scene tape or other obstacles like police officers, police cars or sawhorses, and removing all unnecessary personnel from the scene.
• get the **district attorney** involved, because if anyone could possibly have an expectation of privacy in any portion of the crime scene, the CSI needs **search warrants**.
• begin a walk-through of the crime scene by following a **pre-determined path** that is likely to contain the least amount of evidence that would be destroyed by walking through it. During this initial walk-through, he takes immediate note of **details that will change with time**: What's the weather like? What time of day of day is it? He describes any notable smells (gas? decomposition?), sounds (water dripping? smoke alarm beeping?), and anything that seems to be out of place or missing.
• call in any **specialists** or additional tools that might be needed based on particular types of evidence seen during the recognition stage.
• talks to the first responders to see if they touched anything and gather any additional information that might be helpful
	The goal of crime-scene documentation is to create a visual record that will allow the forensics lab and the prosecuting attorney to easily recreate an accurate view of the scene. The CSI uses digital and film cameras, different types of film, various lenses, flashes, filters, a tripod, a sketchpad, graph paper, pens and pencils, measuring tape, rulers and a notepad at this stage of the investigation. He may also use a camcorder and a camera boom.
	• Note-taking on scene is not straightforward. A CSI's training includes the art of **scientific observation**…in crime scene investigations, opinions don't matter and assumptions are harmful. When describing a crime scene, a CSI makes factual observations without drawing any conclusions.
	• CSIs take pictures of everything before touching or moving a single piece of evidence. There are three types of photographs a CSI takes to document the crime scene:
	  ◦ **Overview shots** are the widest possible views of the entire scene.
	  ◦ **Mid-range photos** show key pieces of evidence in context.
	  ◦ **Close-ups** of individual pieces of evidence, showing any serial numbers or other identifying characteristics.
	  ◦ Every photo recorded in a **photo log**. Documents the details of every photo, includes the photograph number, a brief description, the location, the time, the date, any relevant descriptive details
	• CSIs also create sketches to depict both the entire scene, and particular aspects of the scene that will benefit from exact measurements. The goal is to show locations of evidence and how each piece of evidence relates to rest of scene.
	• Scene documentation may also include a video walk-through

At the Crime Scene : Finding the Evidence	At the Crime Scene : Evidence Collection
The goal of the evidence-collection stage is to find, collect and preserve all physical evidence that might serve to recreate the crime and identify the perpetrator in a manner that will stand up in court. Evidence can come in any form. Some typical kinds of evidence a CSI might find at a crime scene include: • Trace evidence (gunshot residue, paint residue, broken glass, unknown chemicals, drugs) • Impressions (fingerprints, footwear, tool marks) • Body fluids (blood, semen, saliva, vomit) • Hair and fibers • Weapons and firearms evidence (knives, guns, bullet holes, cartridge casings) • Questioned documents (diaries, suicide note, phone books; also includes electronic documents like answering machines and caller ID units) **Examining the scene** There are several search patterns available for a CSI to choose from to assure complete coverage and the most efficient use of resources. • The **inward spiral** search • The **outward spiral** search • The **parallel** search • The **grid** search • The **zone search** The actual collection of physical evidence is a slow process. Each time the CSI collects an item, he must immediately preserve it, tag it and log it for the **crime scene record**. Different types of evidence may be collected either at the scene or in lab depending on conditions and resources.	In collecting evidence from a crime scene, the CSI has several main goals in mind: Reconstruct the crime, identify the person who did it, preserve the evidence for analysis and collect it in a way that will make it stand up in court. • **Trace evidence** Trace evidence might include gun-shot residue (GSR), paint residue, chemicals, glass and illicit drugs. To collect trace evidence, a CSI might use tweezers, plastic containers with lids, a filtered vacuum device and a knife. He will also have a biohazard kit on hand containing disposable latex gloves, booties, face mask and gown and a biohazard waste bag. • **Body fluids** Body fluids found at a crime scene might include blood, semen, saliva, and vomit. To identify and collect these pieces of evidence, a CSI might use smear slides, a scalpel, tweezers, scissors, sterile cloth squares, a UV light, protective eyewear and luminol. • **Blood spatter patterns**. These patterns can reveal the type of weapon that was used, which direction the blood came from, and how many separate incidents created the pattern. • **Hair and Fibers** A CSI may use combs, tweezers, containers and a filtered vacuum device to collect any hair or fibers at the scene. • **Fingerprints** Tools for recovering fingerprints include brushes, powders, tape, chemicals, lift cards, a magnifying glass and Super Glue. A crime lab can use fingerprints to identify the victim or identify or rule out a suspect. • **Footwear Impressions and Tool Marks** A casting kit might include multiple casting compounds (dental gypsum, Silicone rubber), snow wax (for making a cast in snow), a bowl, a spatula and cardboard boxes to hold the casts. • **Firearms** If a CSI finds any firearms, bullets or casings at the scene, she puts gloves on, picks up the gun by the barrel (not the grip) and bags everything separately for the lab. • **Documents** A CSI collects and preserves any diaries, planners, phone books or suicide notes, any signed contracts, receipts, a torn up letter in the trash or any other written, typed or photocopied evidence that might be related to the crime.

Questions

1. Looking through the information listed in the model; describe each of the following jobs that are pertinent to the accurate processing of a crime scene and analyze there use in the CSI video clip:

   Leader –

   Photographer –

   Note Taker –

   Sketch Artist –

   Evidence Collector –

2. List as many 'specialized' jobs that might be required as additional experts for the crime scene in the video clip:

3. a. Several search patterns are identified in model 1 and the lecture – which search pattern would you choose to analyze the crime scene in the video clip and why?

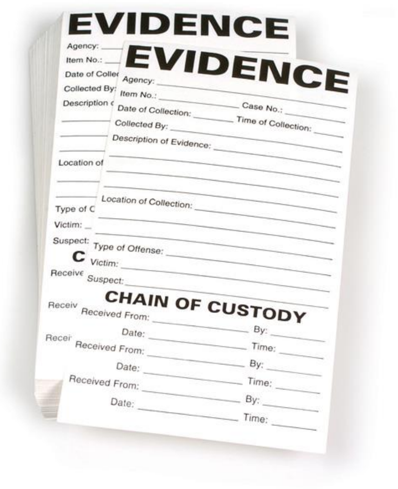
b. If you were analyzing the OJ Simpson crime scene, would you choose a different search pattern? Why or why not?

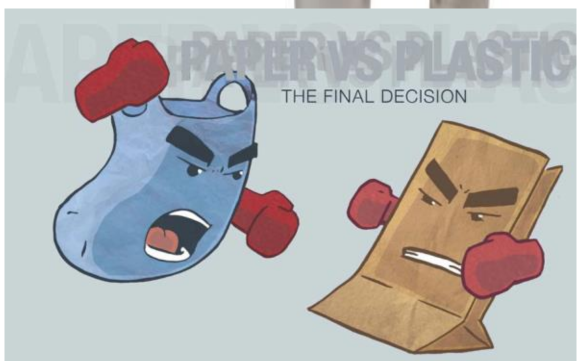
Exercises

5. The first rule of protecting a crime scene is ensuring that no one enters the scene – this prevents the danger of contamination of evidence – yet there is one important exception to this rule… What do you believe that exception is?

6. You find a small piece of evidence, but the corner guide you normally use in the photographing of evidence that size is missing… What do you do?

Model 2: Chain of Custody





<u>**Plastic**</u>	<u>**Paper**</u>	<u>**Can**</u>
Dry evidence since there's no concern about degradation	**Wet evidence so the material can't degrade due to the moisture being trapped in**	**Evidence that might have an evaporate you need to keep**

There's a rule of thumb for other types of evidence, too, and here's a handy list for the proper packaging of those items.

Hair – Double packaging in paper is best. However, if the hair is completely dry, plastic will work in a pinch. Hairs recovered from different locations must be packaged separately and labeled accordingly. Tape all packaging seams.

Fibers – Dry, and tape-lifted, fibers may be placed inside plastic containers.

Rope, twine, and other cordage – Paper or plastic.

Paint chips – Place inside folded paper. Then place the paper fold inside an envelope.

Tools – Paper or cardboard.

Tape – Wear non-powdered gloves when handling tape. Submit samples inside plastic. If the tape is stuck to an item the item must be submitted with the tape still attached. Do not remove the tape!

Glass – Wrap in paper. Smaller pieces may be placed inside appropriate size cartons.

Arson and other fire evidence – Airtight metal containers. Unused paint cans work best.

Dried stains – Wrap stained item in paper or place inside cardboard box. Large items – moisten swab with distilled water, swab the stain, and package in paper or cardboard after drying.

Blood - Allow to air dry and then package in paper, if you're hoping for **DNA** – NEVER use plastic!

Questions

1. Describe why an evidence collector would choose to use a paper bag to collect evidence and list a minimum of three examples of evidence that should be collected and stored in a paper bag:

2. Describe why an evidence collector would choose to use a plastic container to collect evidence and list a minimum of three examples of evidence that should be collected and stored in a plastic container:

3. Why do you think arson evidence would need a special container for collection and preservation? What might an evidence container for arson evidence look like?

Exercises

1. The following evidence has been identified and needs to be collected: what will you use as packaging to preserve the sample?

   Clothing from a rape victim:

   Carpet fibers found on the body of a victim dumped in the woods:

   Swatch of carpet from an apartment determined to be the starting point of a fire:

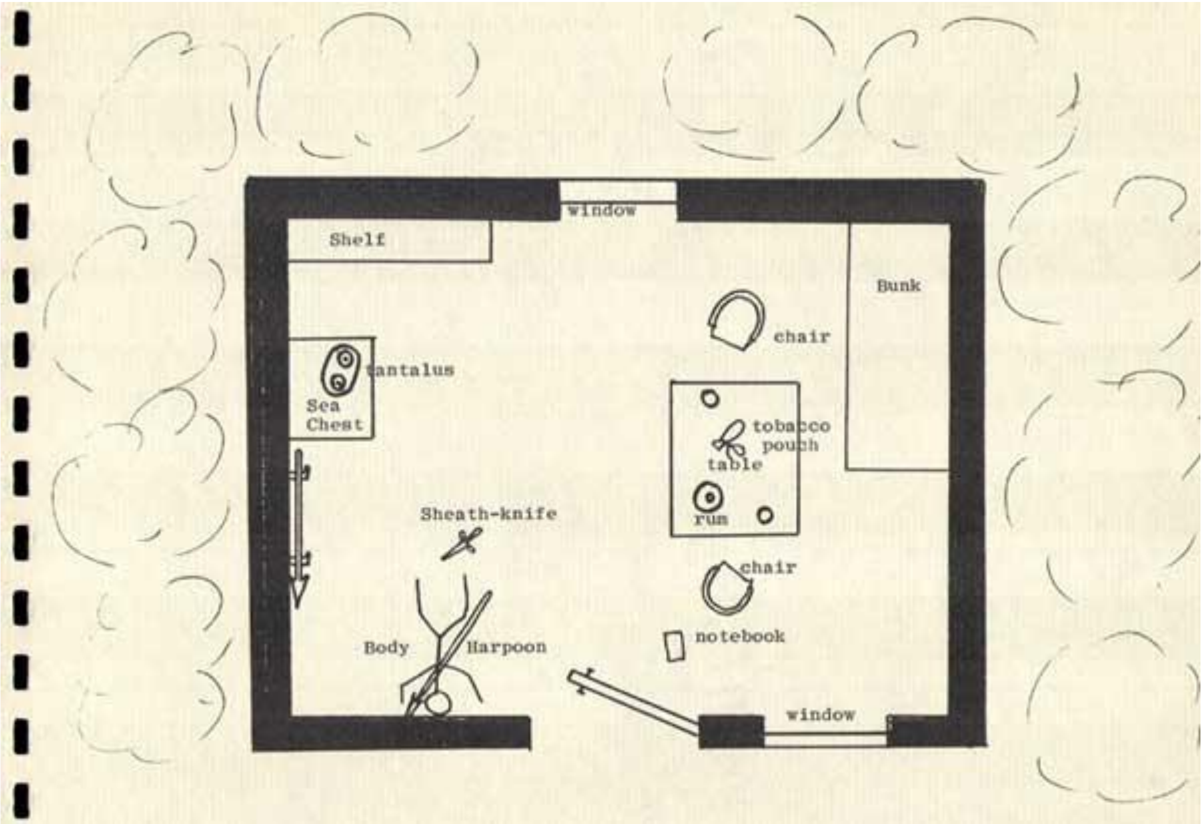
   Paint chips recovered from a vehicle that was sideswiped by another vehicle:

   Blood drops located on the ceiling tiles above the victim:

   Pieces of shattered glass found inside on the carpet after a break-in:

Problems

It’s time to put it into action… You have been called to the following crime scene… Now what?



Identify and discuss how you would analyze this scene…

Be sure to show one example of triangulation on the diagram above…

References:
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Websites –
http://investigation.discovery.com/tv-shows/cold-blood/videos/cold-blood-processing-crime-scenes.htm

DNA Analysis

How is a blood sample prepared and analyzed to create a DNA analysis?

Why?

You may remember DNA being referred to as the "blueprint of life". Every living thing has a genetic code hidden inside every nucleus of every cell in the organism, decoding that genetic code is a relatively new technique applied to Forensic Science. The sequencing of that genetic code is unique to individuals and allows a scientist to create an image of that genetic code – an image that is an excellent source of individualizing evidence.

Learning Outcome

- Students will be able to identify the components of a DNA strand and how they interact to create the double helix
- Students will be able to understand the creation of a gel electrophoresis test, as well as read the results of such a test
- Students will be able to understand the creation of a STR test, as well as read the results of such a test.

New Concepts

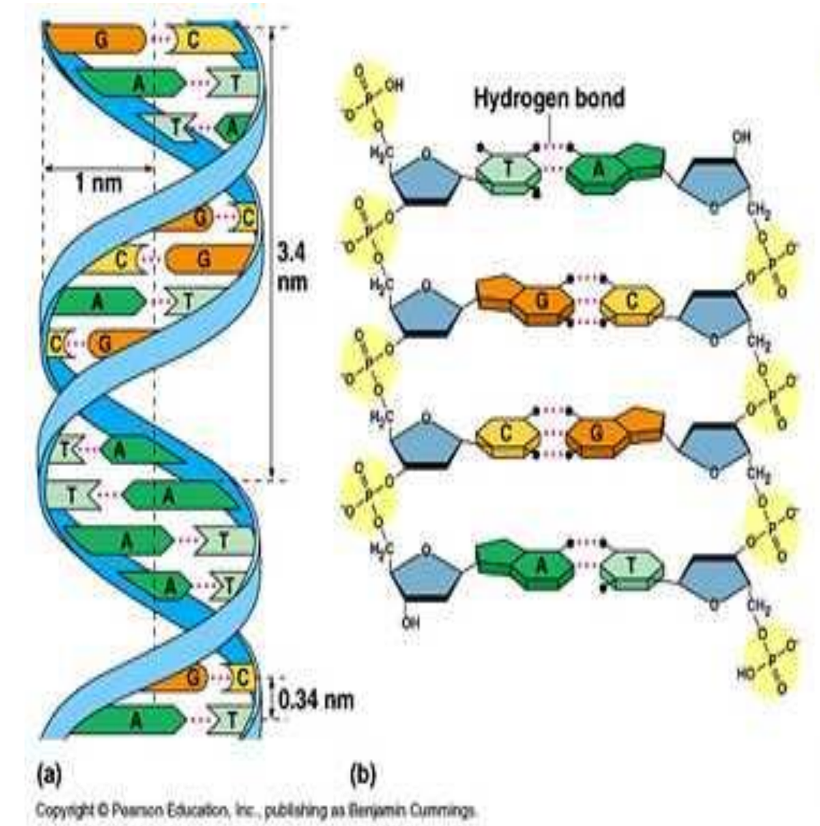
Nucleic Acids, VNTR, PCR, RFLP, Gel Electrophoresis, STR.

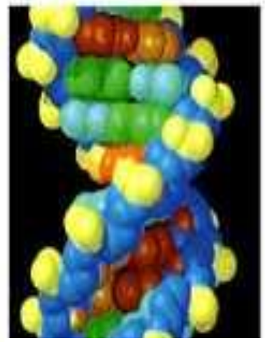
Prerequisites

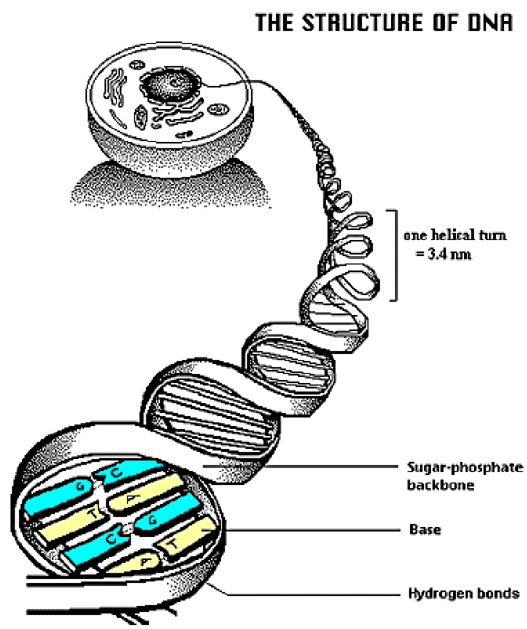
- Protein synthesis, translation of DNA, chromosomes, genes, human reproduction

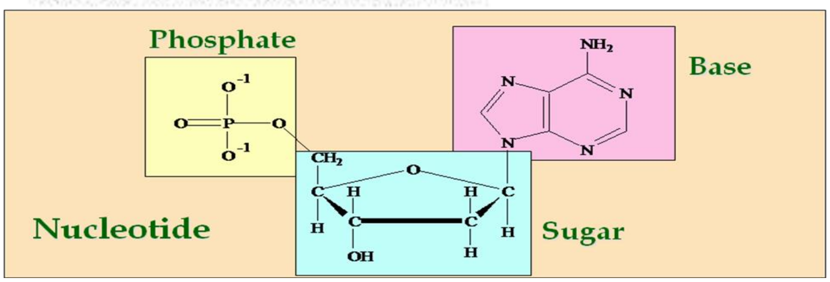
Reading Assignment

Model 1 : Nucleic Acids → DNA









The DNA strand is a polymer made up a monomers consisting of a phosphate, a sugar, and a base. The nitrogenous base can be one of four: adenine, guanine, cytosine and thymine. The two strands of DNA are held together by a very strong intermolecular force of attraction called a hydrogen bond. The nitrogenous bases always line up with an adenine attracted to a thymine and a cytosine attracted to a guanine. This knowledge has allowed us to break apart the DNA strand, duplicate strands, and begin to understand exactly what a DNA strand codes for in the organism. DNA is located inside the nucleus of every cell nucleus inside the organism, tightly wound into chromosomal pairs. This nuclear DNA has ½ of the DNA coding from the mother AND ½ from the father of the organism. Another source of DNA is located in the mitochondria of the organism, although this DNA source is coded from the mother only.

Questions

1. What is the monomer of DNA called? What are its components?

2. What are the four nitrogenous bases and how do they pair up inside the DNA strand?

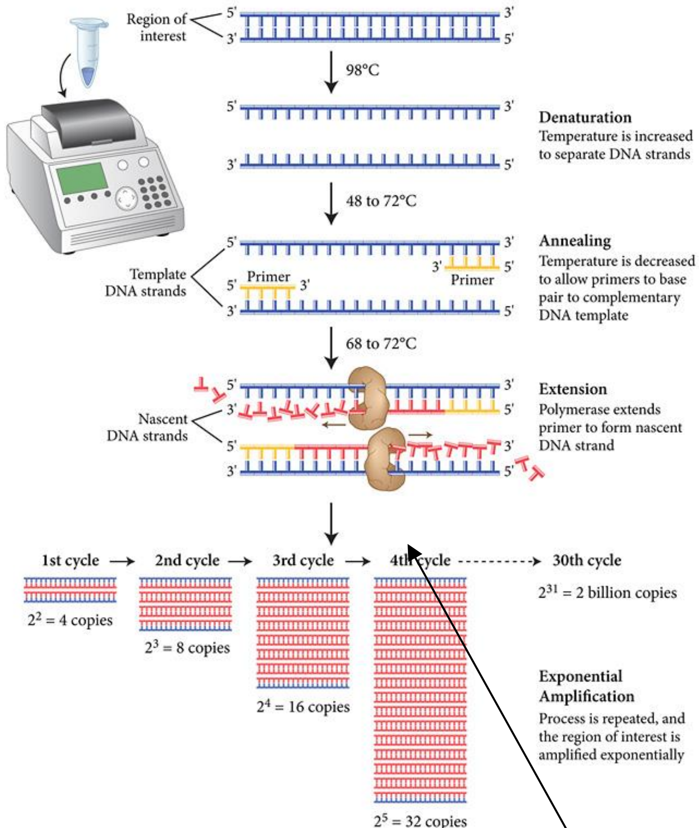
3. Where is the DNA strand actually found in the organism? What does that mean to forensic science?

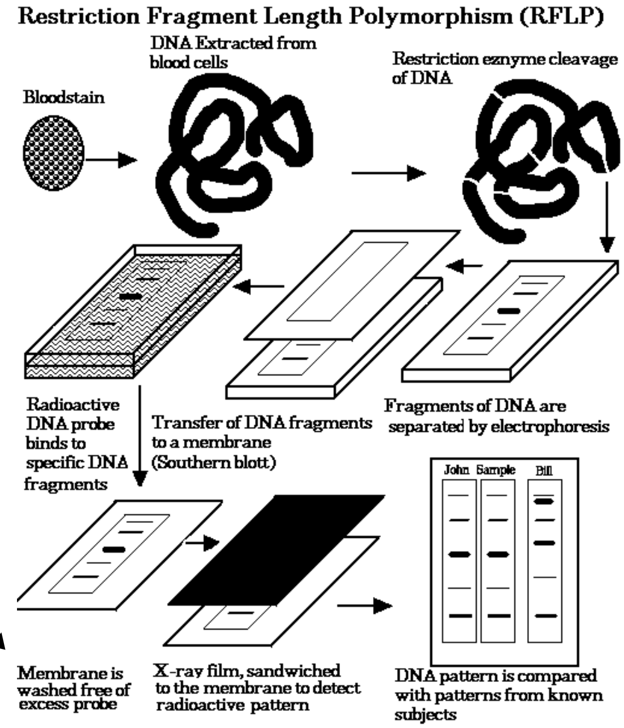
Exercises

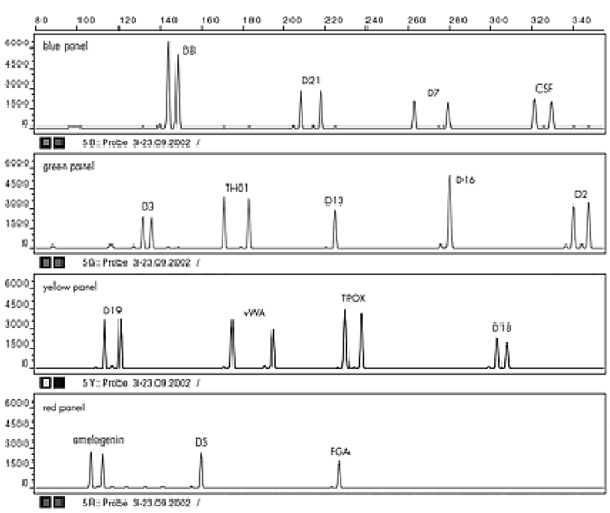
7. Propose samples of evidence that could be taken from a crime scene that could be potentially rich sources for DNA evidence

8. Can DNA be utilized for other purposes than crime scene investigations?

Model 2 : DNA Analysis I







- Separation and Purification of DNA then
- Replication of certain portions of DNA, known as Short - Tandem Repeats (STR markers) through Polymerase Chain Reaction (PCR)
- Cutting the DNA into fragments using enzymes that recognize specific codes in the DNA strand is done during Restriction Fragment Length Polymorphism (RFLP), Separating the DNA strand fragments using electricity – the smaller the fragments the farther along the gel they can move with the electricity (gel electrophoresis), Reading the darkened bands on the gel, can be between 25 and 60 bands depending on the enzyme used ; 1 in 1,000,000 will have the same band pattern
- Alternative uses Short Tandem Repeats (STR)

Questions

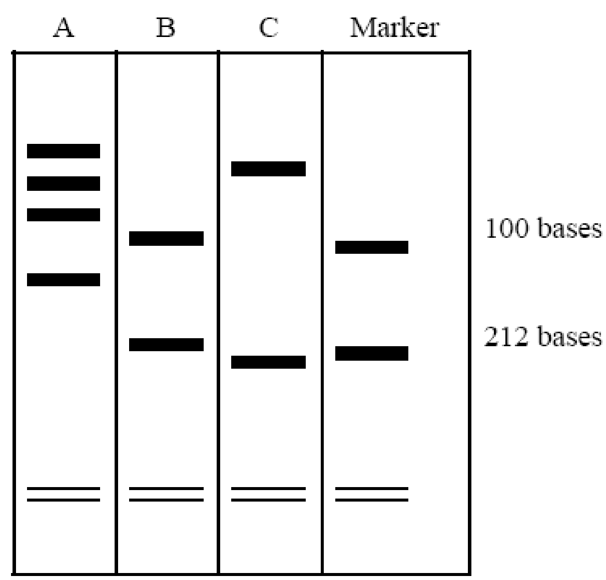
1. List the sequence of events in your own words, in order, that takes place when analyzing DNA strands that will lead to a Gel Electrophoresis result.

2. Examining the gel at the right, answer the following basic questions before going on the exercises:

a. Label the wells, or origin of samples, in the gel:

b. Label the positive and negative ends to the gel:

c. Which fragments travel the farthest?



3. How many STR's do we know about that can be seen on an STR result (an example is in the model)

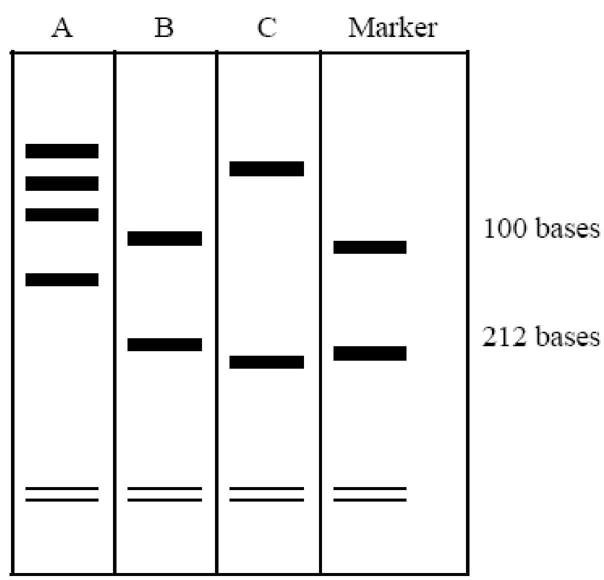
4. Why do some the STR's appear as two peaks, when some only appear as 1 peak?

Exercises

9. Looking at the gel provided in question 2: answer the following questions…
   a. Three enzymes were used to cut the fragments, but were not labeled; use the following information to determine which enzymes are A, B, and C in the diagram.
   - Enzyme Bam HI made three cuts to the DNA strand
   - Enzyme Dra I made one cut to the DNA strand leaving two fragments within 100 bases of each other
   - Enzyme Bgl II made one cut to the DNA strand leaving two fragments, one approximately 1/3 the size of the other

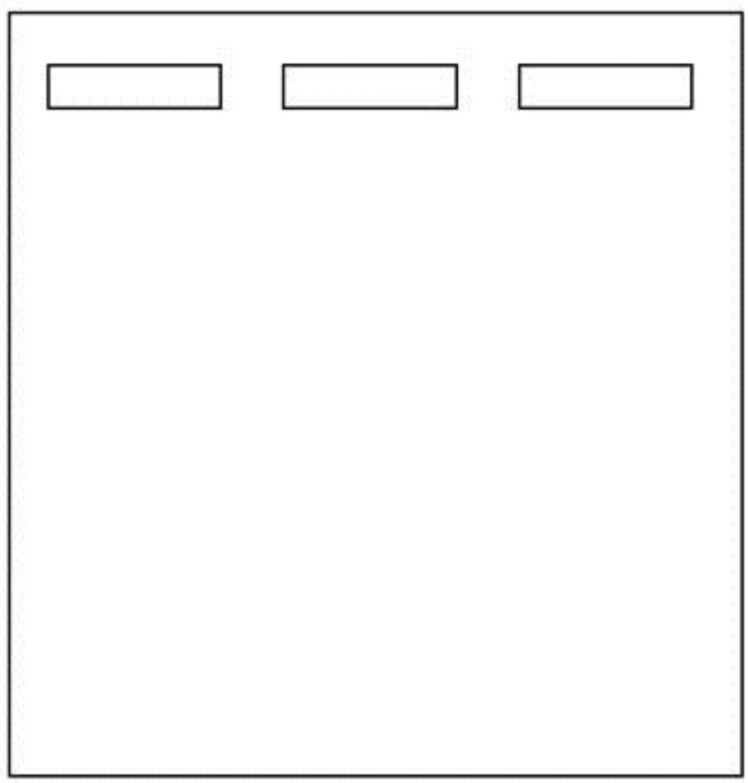
   b. The following base fragments were counted, label them on the provided diagram:

38 bases
115 bases
54 bases
63 bases
89 bases
105 bases
167 bases
219 bases
226 bases
238 bases



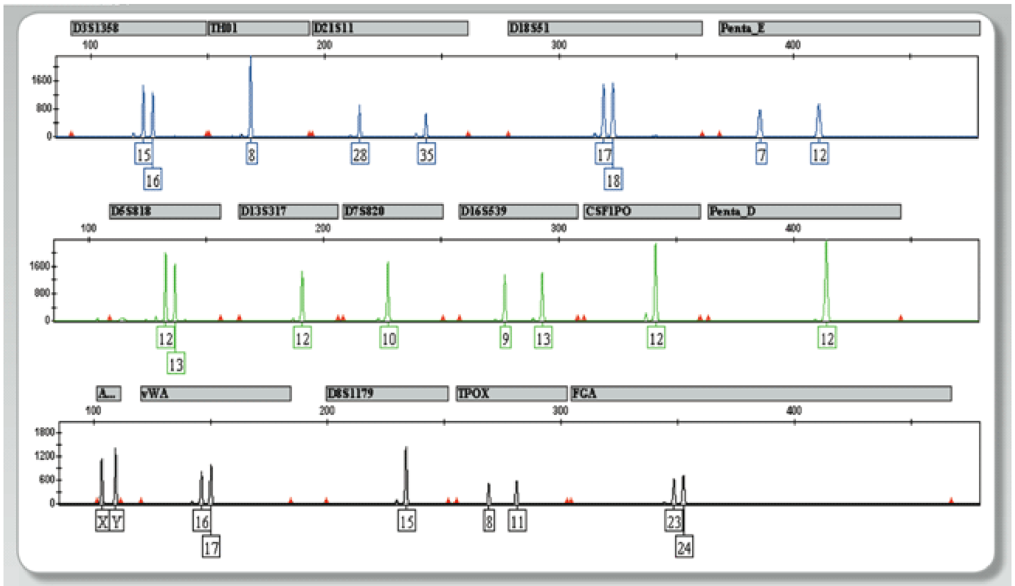
Problems

1. On the diagram below, sketch the predicted results if lane #1 was loaded with a sample composed of 4 different types of polypeptides (having 100 amino acids, 175 amino acids, 250 amino acids, 300 amino acids), lane #2 was loaded with a sample composed of 3 types of polypeptides (200 amino acids, 250 amino acids, and 350 amino acids) and lane # 3 was loaded with a sample of 5 different types (100 amino acids, 150 amino acids, 175 amino acids, 250 amino acids, 300 amino acids).



2. If each lane represents the proteins from a different species of animal, which two would you say are the most closely related? Why?

3. If this is the child's STR analysis, describe a set of results that would indicate the paternity of the child:



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Fingerprints

How are fingerprints made visible, collected, and analyzed?

Why?

Fingerprints are a unique individualizing characteristic of humans. Even identical twins will have different fingerprints. Fingerprints are formed while a person is still in the womb and are due to friction of the individual in their environment. Once formed, fingerprints will not change throughout a person's lifetime. Every time you touch something you leave behind an imprint of your skin, sometimes it's visible, sometimes it's not, but it is there, waiting to be found.

Learning Outcome

- Students will be able to identify the difference between latent and visible prints.
- Students will be able to distinguish between the techniques used to expose latent prints for collection.
- Students will be able to analyze fingerprint patterns, using both common types and minutiae.

New Concepts

Skinprints are friction ridges formed on hands, feet, ears, or lips. These friction ridges are formed underneath the skin and as long as the dermal layer stays intact, the skinprints stay the same and will come back after injury.

These prints are left behind as impressions into a surface or deposited as a thin film of water and oils secreted by the body. Making a print visible means reacting with the depositions left behind.

There are basic types of fingerprints as well as numerous minutiae that are used to categorize fingerprints.

Prerequisites

- Individual vs. Class characteristics

Reading Assignment

Saferstein, 8th edition, pg. 406-429

Model 1 : Visible vs. Latent Prints

For a given set of circumstances, the choice of the best detection techniques, or sequence of techniques, will depend on several factors that include: the nature of the surface (eg, porous, non-porous, rough or smooth); the presence of any particular contaminants (eg, blood); environmental factors (eg, whether or not the surface is or has been wet); and, the likely age of any evidential finger marks.
In any fingerprint detection sequence, heavy emphasis should be placed on optical techniques, as these are non-destructive and may significantly improve the results obtained by physical or chemical methods. Other techniques must be applied with caution, and developed prints recorded at each opportunity, as finger marks are fragile and readily destroyed.

	Techniques for Visualization	Collection as Evidence	Examples
Latent	• Dusting : suitable for hard or non-porous surfaces only where the secreted oils will sit above the surface and adhere the dust to create a liftable print • Luminescence : some components of sweat are luminescent and fluoresce when illuminated with lasers. Some fluorescent dyes do not require laser excitation. • Iodine fuming or Physical Developers (silver nitrate): suitable for a porous material where the oils have been absorbed. The iodine is believed to dissolve in the skin oils that make up the print (temporary and will fade). • Ninhydrin: suitable for a porous material where the oils have been absorbed. A Colorless compound reacts with amino acids in sweat to form a purple colored compound. • Superglue fuming: suitable for hard or non-porous surfaces only where the secreted oils can come into contact with the Cyanoacrylate ester and polymerize. The visible prints produced are white, but are often treated with a fluorescent dye to improve visibility.	Once visualization is complete, the print is photographed and lifted with an evidence card that has tape attached to a cardboard backing, often marked with the metric system scale	-Any skin surface that has come into contact with another solid surface allowing the transference of natural oils and sweat from the body
Visible	No need for a visualization technique to be utilized. These prints can be 'negative' or 'positive' depending on what the print was left in. A negative print is one where the person removed soot or a dust to expose their print while a positive print has been left behind in a substance that has been transferred from the person to a surface where it has dried in a clearly visible pattern	The print is photographed and lifted with an evidence card that has tape attached to a cardboard backing, often marked with the metric system, if possible	- Skin surfaces that have come into contact with a fluid that does not dry clear, such as paints or blood
Plastic	No need for a visualization technique to be utilized – generally made visible through oblique lighting. These prints have been left behind in a substance that has been transferred from the person to a surface where they have dried in a clearly visible pattern	The print is photographed and a casting made if the surface itself cannot be collected into evidence	-Skin surface that have come into contact with a soft putty like material that molds to the shape of the skin

Questions

1. What needs to be taken into consideration when deciding which visualization technique should be used?

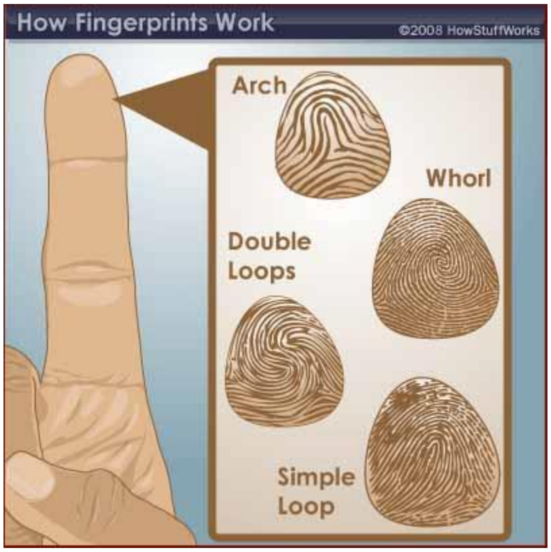
2. Which types of fingerprints require no physical or chemical visualization technique to be seen?

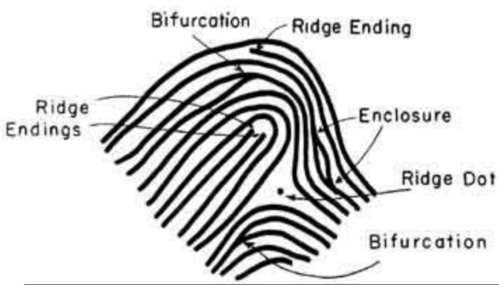
3. Which techniques would you use on a hard, glassy surface?

4. Which techniques would you use on a piece of paper or cardboard?

Model 2 : Using a fingerprint for identification

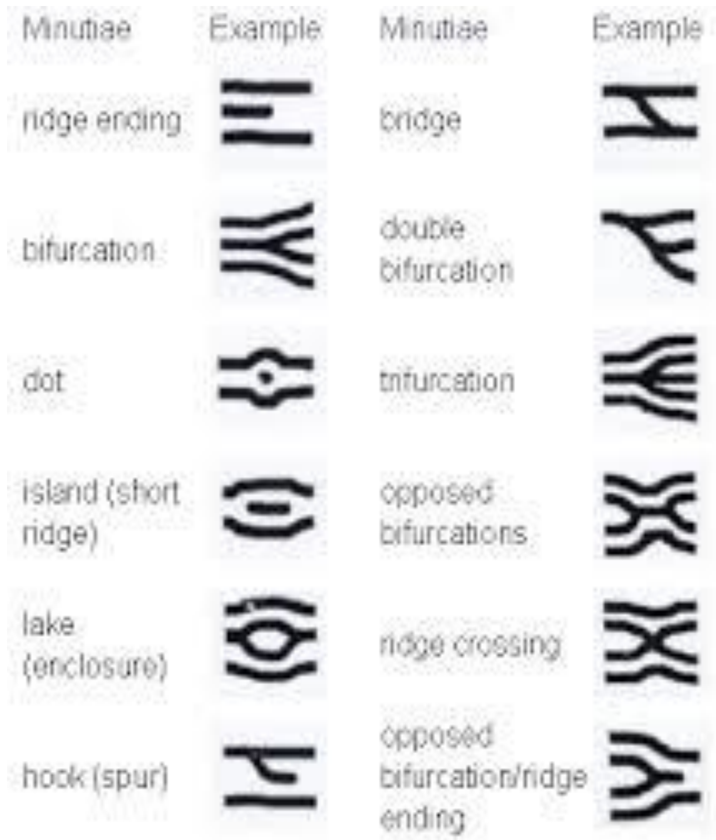
Basic Types…





Application to a print

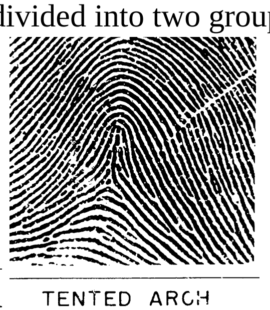
Minutiae



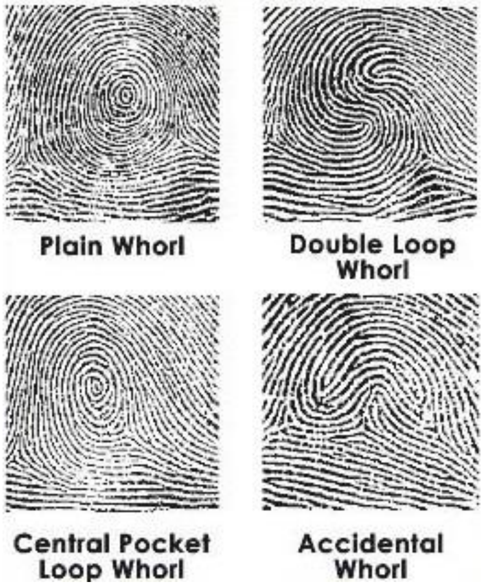
Questions

1. What are the three basic types of fingerprints?

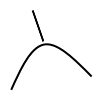
2. Arches can be subdivided into two groups, how would you describe the difference:



3. Whorls can be subdivided into groups, how would you describe the differences:



4. Loops and Whorls have a distinguishable minutiae known as a delta, which is created by the curvature of ridge endings forming the following shape…



   (a) Identify the number of deltas you should find on a whorl fingerprint:

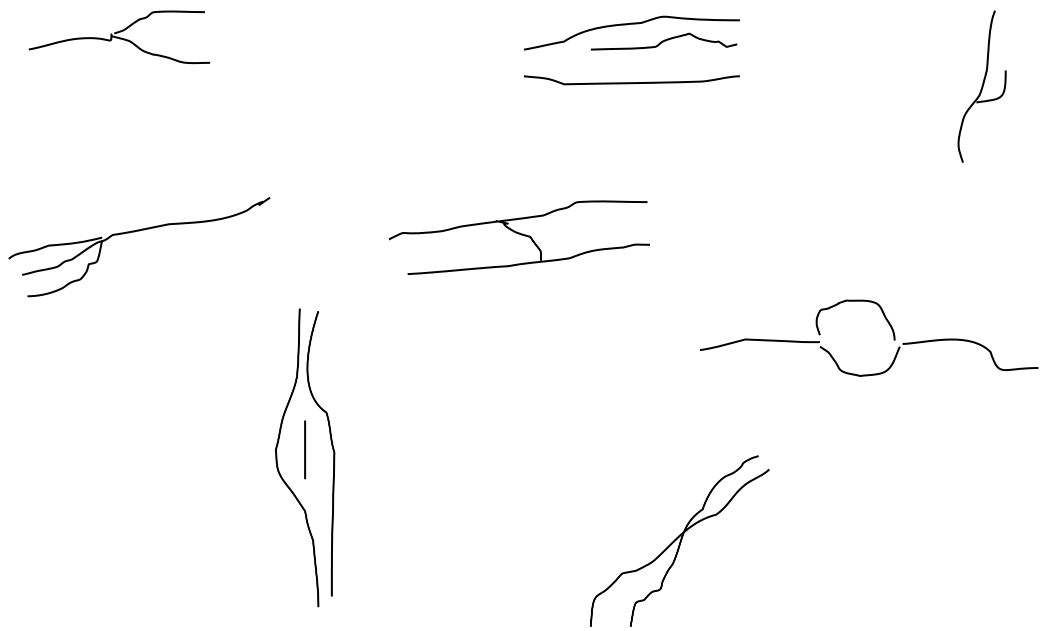
   (b) Identify the number of deltas you should find on a loop fingerprint:

5. Looking at your own fingerprints, which types of fingerprints do you have?

6. Are fingerprints the only type of skin print an investigator could anticipate at a crime scene? Briefly explain:

Exercises

10. Label the following minutiae:



11. Circle and label 7 minutiae on the following print:

References:
Images:
http://s.hswstatic.com/gif/fingerprint-2.gif, viewed 3/2010
https://www.cis.rit.edu/research/thesis/bs/1999/chang/images/minutiae.jpg, viewed 3/2010
https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQmhkIa0ezwof0EheC2FBZUBy2SDIGOB0dXBGDSY7mLu-QOSbGy, viewed 3/2010
http://sites.psu.edu/jlipton/wp-content/uploads/sites/13235/2014/06/plainarch.gif, viewed 3/2010
http://www.sfis.ca.gov/images/image10.gif, viewed 3/2010
http://thedeltacs.com/wp-content/uploads/2012/03/fingerprint-whorls1.jpg, viewed 3/2010

Handwriting and Voice Print Analysis

How can the analysis of handwriting be quantized? What aspects of voice analysis allow the investigator to match a known and unknown?

Why?

As with any science, developments in Forensic Science can be examined to show the progression of it by examining historic events. These milestones have also shaped the organization of a crime laboratory, the types of evidence examined, and the analysis of that evidence. Lastly, the inclusion of evidence into the courtroom should be included in this historic examination.

Learning Outcome

- Students will be able to identify the characteristics and techniques used during handwriting analysis
- Students will be able to identify the characteristics and techniques used during voice analysis

New Concepts

There are subconscious patterns found in handwriting which make it unique.

The act of bringing imprinted evidence back to the surface is dependent on the pressure used by the writer, as it's pressure memory scientists are using.

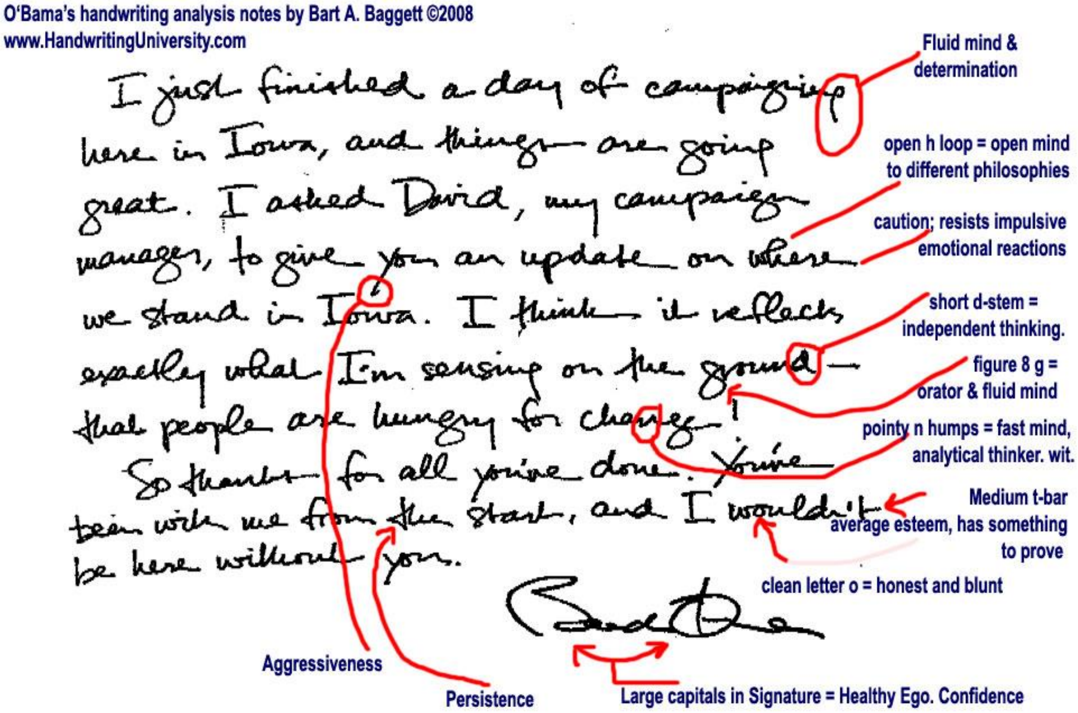
A persons voice is unique to them based on biological systems and geographic history.

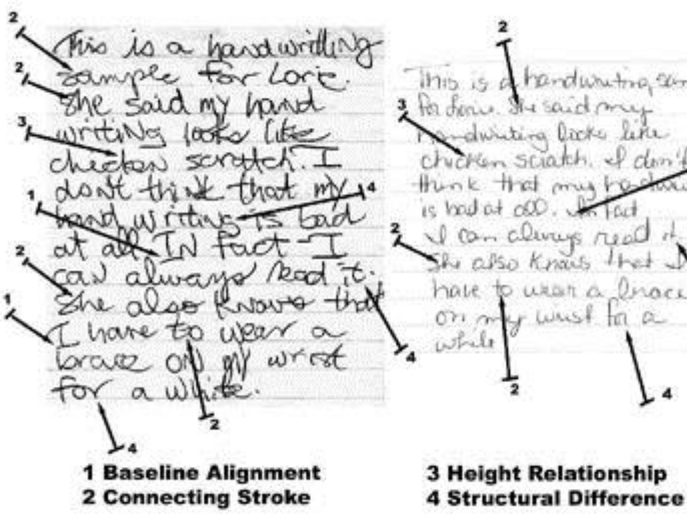
Prerequisites

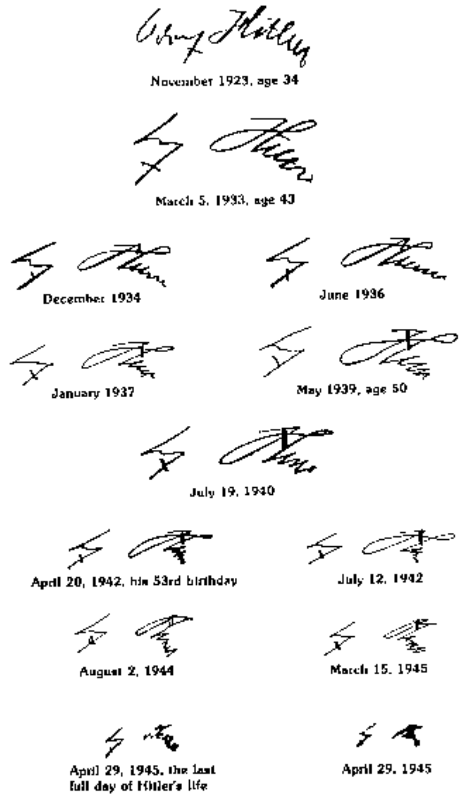
- none

Reading Assignment

Model 1 : Handwriting Analysis







Questions

1. List the factors used when analyzing handwriting samples?

2. Why is it important to obtain a current example of someone's handwriting?

Exercises

3. Do you always write the same way? What else should an analyst think about when trying to match two samples?

Model 2 : Recovering a Document

The use of low angle oblique light and photography is a simple method of analyzing indented writing. Our experts utilize the latest in forensic technology in the course of QDE. You can experiment with this process at home with a flashlight.

Questions

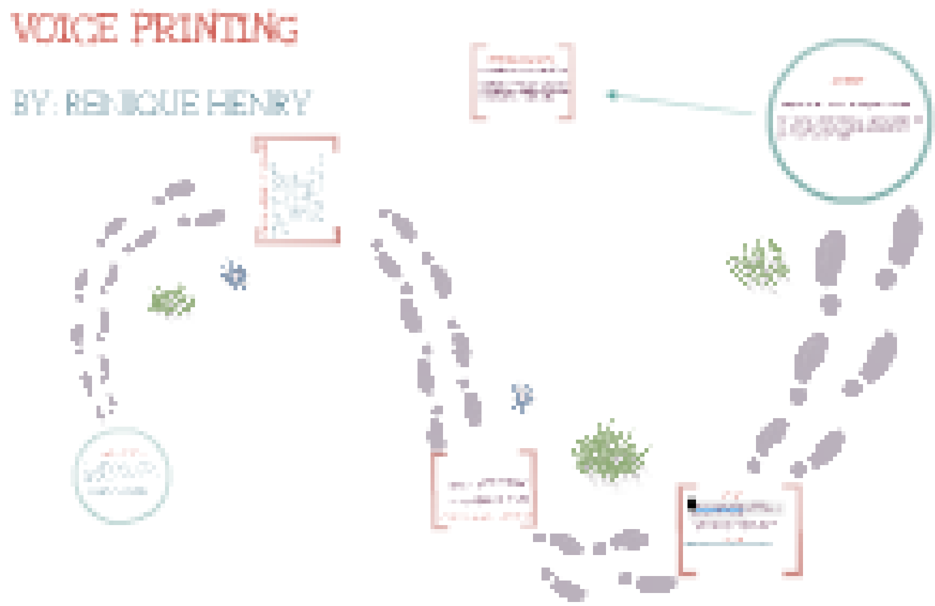
1. There are two techniques that can be utilized to expose indentations left behind on blank papers… Identify and describe each:

   (a)

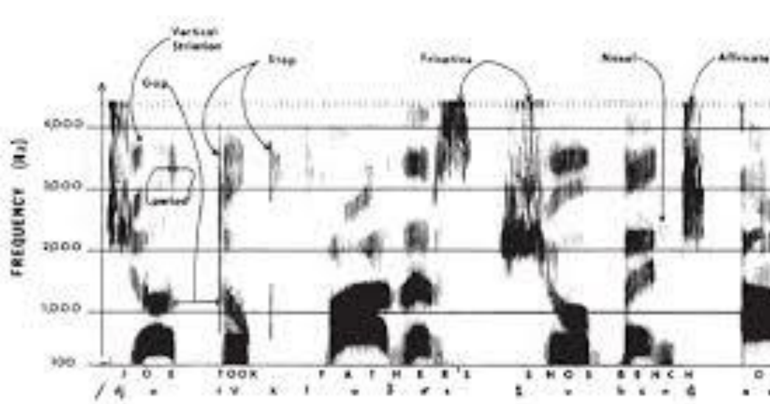
   (b)

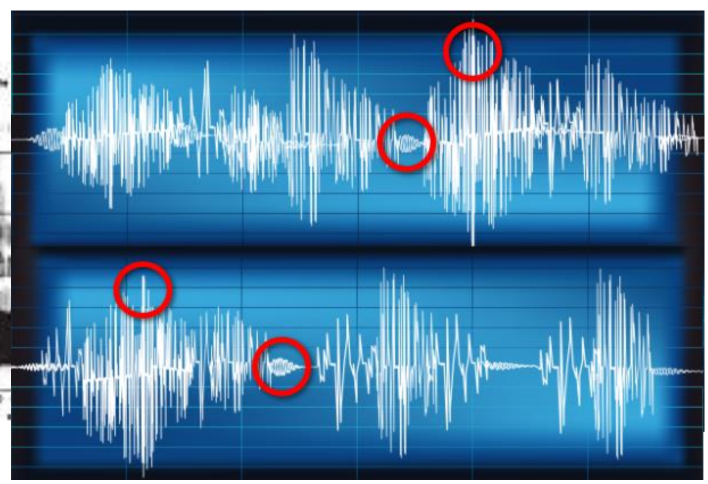
2. Is there a technique not shown here that you may have used yourself as a child? What is it?

Model 3 : Voiceprint Analysis



*This is a prezi hyperlink in the digital copy, website below…
https://prezi.com/eitigeyzfw0r/voice-print-analysis/





Questions

1. What are the three components displayed by a voiceprint analysis?

2. Can something alter your voiceprint?

Problems

3. Two basic characteristics define how we create our speech patterns. Under each heading list a minimum of three examples of that characteristic:

Biological Parameters	Articulators

References:
Images:
http://www.viewzone.com/handwriting.obama.jpg, viewed 3/2011
http://www.fbi.gov/about-us/lab/forensic-science-communications/review/Images%20(review02)/Figure%2010%20with%20legend%20edit.jpg, viewed 3/2011
http://rexcurry.net/swastika-socialism4.gif, viewed 3/2011
http://www.dojni.gov.uk/esda-blur.jpg, viewed 3/2011
http://sifsindia.com/images/Signature1.png, viewed 3/2011
http://www.robsonforensic.com/upload/articles/Questioned-Document-Header.jpg, viewed 3/2011
http://www.drdennistanner.com/images/Voice%201.gif, viewed 3/2011
http://www.victrio.com/images/voice_pattern_matching_610x410.png, viewed 3/2011

Webpages:
https://prezi.com/eitigeyzfw0r/voice-print-analysis/

Historic Development of Forensic Science

What are the important developments that mark the progression of Forensic Science?

Why?

As with any science, developments in Forensic Science can be examined to show the progression of it by examining historic events. These milestones have also shaped the organization of a crime laboratory, the types of evidence examined, and the analysis of that evidence. Lastly, the inclusion of evidence into the courtroom should be included in this historic examination.

Learning Outcome

- Students will be able to identify the persons and events that mark the development of Forensic Science.
- Students will be able to identify the services provided by crime laboratories, from full service to specialties.
- Students will be able to identify the four court cases most often used in establishing the acceptability of evidence/testimony in the courtroom

New Concepts

There are nine prominent men that accredited for the progression of Forensic Science through history.

The organization of a crime laboratory can be subdivided into the types of evidence analyzed in that department

Prerequisites

- none

Reading Assignment

Saferstein, 8th edition, pg. 1-22

Model 1 : Team Building

You should now be in a group of three to six. In that group, job assignments need to be given each time a POGIL is assigned during class – it is recommended that the students in the group rotate through the job assignments. On the provided worksheet, list the names of the people in your POGIL group and the jobs that have been chosen for this evening. You will be expected to get into these same groups of four during each POGIL activity.

Job assignments:

Manager – actively participates, keeps the team focused on the task, distributes work and responsibilities, resolves disputes, and assures that all members participate and understand.

Recorder – actively participates, keeps a record of the assignment and what the team has done, and prepares a report in consultation with the others.

Spokesperson – actively participates and presents reports and discussion to the class.

Strategy Analyst - actively participates, identifies strategies and methods for problem solving, identifies what the team is doing well and gets an instructors attention when a consultation is needed

POGIL Team Building

Team Members: ______________________________

____

____

____

____

List team member followed by tonight's role assignment

Your team is the employment committee of a start-up private forensic science company. You are planning to hire several new scientists in the coming months. Identify eight characteristics that you will be seeking in the applicants.

You have five minutes to finish this task before reporting will begin.

1.
2.
3.
4.
5.
6.
7.
8.

Model 2 : Historic Timeline

- **BC**

Evidence of **fingerprints** in early paintings & rock carvings made by prehistoric humans**.**

- 250 … ERASISTRATUS , an ancient Greek physician, observes that his patients' **pulse rates** increase when they tell him lies. This is supposed to be the first **lie detection test**.

- 44 … Ancient Roman physician **ANTISTIUS** examines the dead body of **Julius CAESAR** after his assassination and finds that there are **23 stab wounds**. The only one wound that was fatal, was on the chest.

- **1000 - 1200**

~1300 … In the Yuan Dynasty, a Chinese mandarin named **Sung T'zu** made the first recorded observations of the usefulness of insects in solving crimes – he identified the murderer by watching the flies collect on the farmers scythe

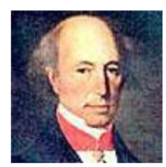
- **1600**

- 1658 … Sir Thomas BROWNE (1605-1682), an English physician, biologist, philosopher, and historian, for many a **pioneering forensic archaeologist**, discovers **adipocere**. In his book "**HYDRIO-TAPHIA, Urne-Burial**" he publishes scientific reference to the fatty, waxy, soap-like substance derived from decayed human corpses buried in moist, air-free places.

- **1700**

- 1784 … In Lancaster UK, **John Toms** is convicted of murder on the basis of the torn edge of a wad of newspaper in a pistol matching a remaining piece in his pocket. This was one of the first known documented uses of **physical matching**.

- **1800**



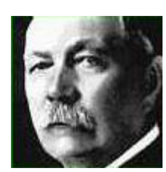
- 1813 … Mathieu Bonaventure ORFILA (1787-1853), professor of medicinal and forensic chemistry at **Univ. of Paris**, publishes **Traite des Poisons**. Considered the father of modern toxicology. Significant contributions to development of tests for the presence of blood in a forensic context. Credited as the first to attempt the use of a microscope in the assessment of blood and semen stains.

- 1830's … Lambert Adolphe Jacques QUÈTELET, a Belgian statistician, provides the foundation for **BERTILLON** 's work by stating his belief that no two human bodies were exactly alike.

- 1853 … Ludwik Karol TEICHMANN (1823-1895), Polish anatomist, attended medical school in **Göttingen**, Germany, and after graduation remained there as prosector of anatomy. In an 1853 paper on the crystallization of certain organic compounds of the blood, he describes the preparation of microscopic **crystals of hemin**. The simple, specific test developed by **TEICHMANN** for the presence of blood in suspect stains on clothes and other items became widely used in forensic medicine, a similar microcrystalline test was created in 1912 by **TAKAYAMA**

- 1880's … Dr. Henry FAULDS forwards an explanation of his fingerprint classification system to **Sir Charles DARWIN**, who is too ill to be of assistance. **DARWIN** passes the material to his cousin **Francis GALTON**.

- 1883 … Alphonse BERTILLON, a French police employee, identifies the first recidivist based on his invention of **anthropometry**.

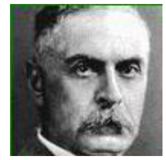


- 1887 … Arthur Conan DOYLE publishes the first **Sherlock Holmes** story in **Beeton's Christmas Annual of London**.

- 1889 … Alexandre LACASSAGNE, professor of forensic medicine at the University of Lyons, France, was a principal founder in the fields of medical jurisprudence and criminal anthropology.

- 1892 … Sir Francis GALTON, a British anthropologist and a cousin of **Charles DARWIN**, publishes his book, "Fingerprints", establishing the individuality and permanence of fingerprints and a first classification system. **GALTON** identifies the characteristics by which fingerprints can be identified (**minutia**), basically still in use today

• 1900



- 1901 … Karl LANDSTEINER first discovers **human blood groups** and is awarded the **Nobel Prize** for his work in 1930. **Max RICHTER** adapts the technique to type stains. This is one of the first instances of performing validation experiments specifically to adapt a method for forensic science. **LANDSTEINER**´s continued work on the detection of blood, its species, and its type forms the basis of practically all subsequent work.

- 1904 … LOCARD publishes **L'enquete criminelle et les methodes scientifique**, in which appears a passage that may have given rise to the forensic precept that "Every contact leaves a trace." In 1918 he first suggests 12 matching points as a positive fingerprint identification, and fully enunciates the Locard's Exchange Principle in 1920

- 1915 … Leone LATTES, professor at the **Institute of Forensic Medicine** in Turin Italy, develops the first **antibody test for ABO blood groups**. He first uses the test in casework to resolve a marital dispute. He publishes **L'Individualità del sangue nella biologia, nella clinica, nella medicina, legale**, the first book dealing not only with clinical issues, but heritability, paternity, and typing of dried stains.

- 1920 … Calvin GODDARD, with **Charles E. WAITE**, **Phillip O. GRAVELLE,** and **John H FISHER**, perfects the comparison microscope for use in bullet comparison.

- 1923 … In **FRYE v. United States**, polygraph test results were ruled inadmissible. The federal ruling introduced the **concept of general acceptance** and stated that polygraph testing did not meet that criterion.

- 1983 … The **Polymerase Chain Reaction** (PCR) is first conceived by **Kerry MULLIS**, while he is working at **Cetus Corporation**. The first paper on the technique was not published until 1985.

- 1984 … Sir Alec JEFFREYS a research fellow at the **Lister Institute**, Leicester University, discovers a method of **identifying individuals from DNA** - Restriction Fragment Length Polymorphism (**RFLP**). He dubs it '**DNA Fingerprinting**' - a revolutionary new technique in Forensic Science, which is perhaps the greatest single Forensic Discovery of the 20th Century.

- 1993 … In **DAUBERT *et al.* v. Merrell DOW**, a U.S. federal court relaxes the **FRYE standard** for admission of scientific evidence and confers on the judge a "**gatekeeping**" role. The ruling cites **Karl POPPER'**s views that scientific theories are falsifiable as a criterion for whether something is "scientific knowledge" and should be admissible.

- 1996 … In the USA, **mitochondrial DNA evidence** is used in a court for the first time. **Paul WARE** is convicted of the rape and murder of a four year old girl after mitochondrial DNA profiling matches him to a hair found on the body of the child.

crimeZZZ.net crimeline * history of forensic science * history of crime Great thanks to many contributors like **Prof. Anil Aggrawal**, **Richard Munroe** B.Sc.,

Questions

1. Identify the science process or principle each of the following scientists is known for:
    - Aphonse Bertillion
    - Arthur Conan Doyle
    - Francis Galton
    - Calvin Goddard
    - Alexndre Lacassagne
    - Karl Landsteiner
    - Leone Lattes
    - Edmond Locard
    - Matheiu Orfila
    - Sung T'zu
    - Teichmann and Takayama

2. Why would Arthur Conan Doyle be included in the above list, when he is not a scientist?

3. Write the groups definition for 'Locard's Exchange Principle':

Exercises

4. What is the definition of Forensic Science?

5. Describe three ways the scientific progression listed in the model has changed the field of Forensic Science:

    (a)

    (b)

    (c)

Problems

6. How do the three ways identified in exercise 2, make the application of science to law/courtroom more difficult?

Model 3 : Court Cases

The law of evidence governs the proof of facts and the inferences flowing from such facts during the trial of civil and criminal lawsuits. Before the twentieth century, evidence law was largely the product of decisional law. During the twentieth century, projects such as the California Evidence Code and the Uniform Rules of Evidence encouraged the codification of those common-law evidence rules. In 1965, Chief Justice Earl Warren appointed an advisory committee of fifteen to draft the new rules. The committee was composed of lawyers and legal scholars from across the country.

How did we get here?

Frye Standard ➢ 1923, polygraph evidence – "…*the evidential force of the principle must be recognized, and while the courts will go a long way in admitting expert testimony deduced from well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs*". – Sets up the scientific field as the "vaildator" for legal admissibility while court determines if principles are "generally accepted".	Daubert Standard ➢ 1993, Birth defects were caused by prenatal ingestion of Bendectin made by Merrill Dow. – The District Court granted Dow summary judgment based on expert testimony that said that maternal use of Bendectin had not been shown to be a risk factor for human birth defects. Although *Daubert* had the testimony of eight other experts who based their conclusions that Bendectin can cause birth defects on animal studies, chemical structure analyses, and the unpublished "reanalysis" of human statistical studies, the court determined that this evidence did not meet the applicable "general acceptance" standard for the admission of expert testimony. The Court of Appeals agreed and affirmed, citing Frye. ➢ Supreme Court - The Federal Rules of Evidence, not Frye, provide the standard for admitting expert scientific testimony in a federal trial.
Kuhmo Tire ➢ 1999 - Tire blowout liability case. – Plaintiff expert wanted to testify that the blowout was due to defect rather than under-inflation. – Did not allow plaintiff expert testimony since the "test" by the expert was unreliable and made up by him (i.e., baseball batter designing his own "strike zone"). – "*…make certain that an expert…employs the same level of intellectual rigor that characterizes the practice of an expert in the relevant field.*" – Supreme Court extended Daubert's holding to include non-scientific expert testimony.	Joiner ➢ 1995 -Case asserted that PCB's caused cancer in plaintiff – Tried to establish a causal link between PCB's and cancer based upon animal models. – "*Conclusions and methodology are not separate. Experts commonly extrapolate from existing data but nothing requires a court to admit opinion evidence that is connected to the data only by the expert themselves*." – The court may conclude that there is too great a gap between the data and the opinion.

Questions

1. Identify the four 'principal court cases' and briefly describe what they have defined as "acceptable" evidence in the courtroom…

    a.

    b.

    c.

    d.

Problems – think back to notes and how important it is to get evidence into the courtroom…

2. In terms of finding evidence, when is a warrant required?

3. What is the 'Fruit of the Poisonous Tree' doctrine?

Human Forensic Anatomy

How is the human body examined to determine possible forensic evidence?

Why?

An autopsy — also known as a post-mortem examination — is a medical procedure that consists of a thorough examination of a corpse to determine the cause and manner of death and to evaluate any disease or injury that may be present. It is usually performed by a specialized medical doctor called a pathologist.

Autopsies are either performed for legal or medical purposes. For example, a forensic autopsy is carried out when the cause of death may be a criminal matter, while a clinical or academic autopsy is performed to find the medical cause of death and is used in cases of unknown or uncertain death, or for research purposes. Autopsies can be further classified into cases where external examination suffices, and those where the body is dissected and internal examination is conducted.

Learning Outcome

- Students will be able to identify the methodology of an autopsy.
- Students will be able to perform a virtual autopsy.

New Concepts

The principal aim of an autopsy is to determine the cause of death, the state of health of the person before he or she died, and whether any medical diagnosis and treatment before death could have been performed.

A forensic autopsy is used to determine the manner of death and in the United States law, deaths are placed in one of five manners:

Natural Accident Homicide Suicide Undetermined

There are differences between manner of death, cause of death, and mechanism of death

Prerequisites

- Basic Human Anatomy

Reading Assignment

Model 1 : Virtual Autopsy

(1) Go to the following website and perform an autopsy.

http://australianmuseum.net.au/interactive-tools/autopsy/

(2) Fill in the information from each section on the Data Table provided.

Data Table

1. List the forensic evidence that might be found during the external exam on the following parts of the body:
    a. Chest –
    b. Fingers –
    c. Shoulders –
    d. Legs –
    e. Elbows –
2. What is the most common way to remove the organs? Describe:
3. Which organs, once removed, are not weighed? Describe what is done instead?
4. Describe the common weights of the remaining organs:
    a. Lungs
    b. Heart
    c. Liver
    d. Kidneys
    e. Brain
5. Describe the stitching used to close up the body after the autopsy is completed:

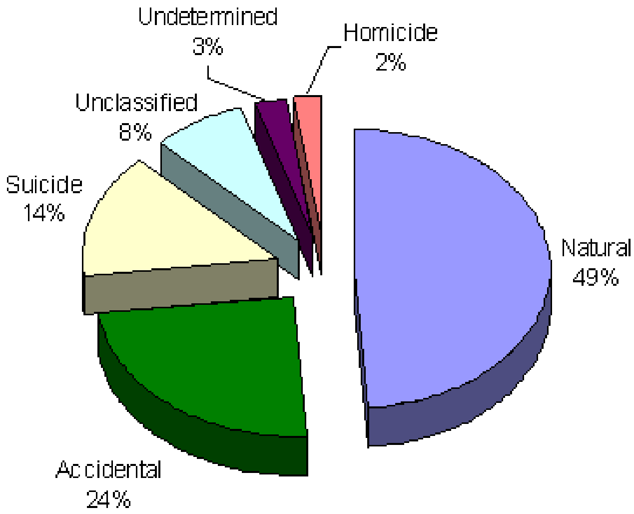
Problems

(1) What is the reason for clearing the intestines and stomach and examining the contents?

(2) Is there another choice for an autopsy if the family insists that the body not be cut for religious purposes? Describe if there is:

(3) Can a family request an autopsy? Deny the medical examiners office the right to perform an autopsy?

Model 2 : Manner, Cause, and Mechanism

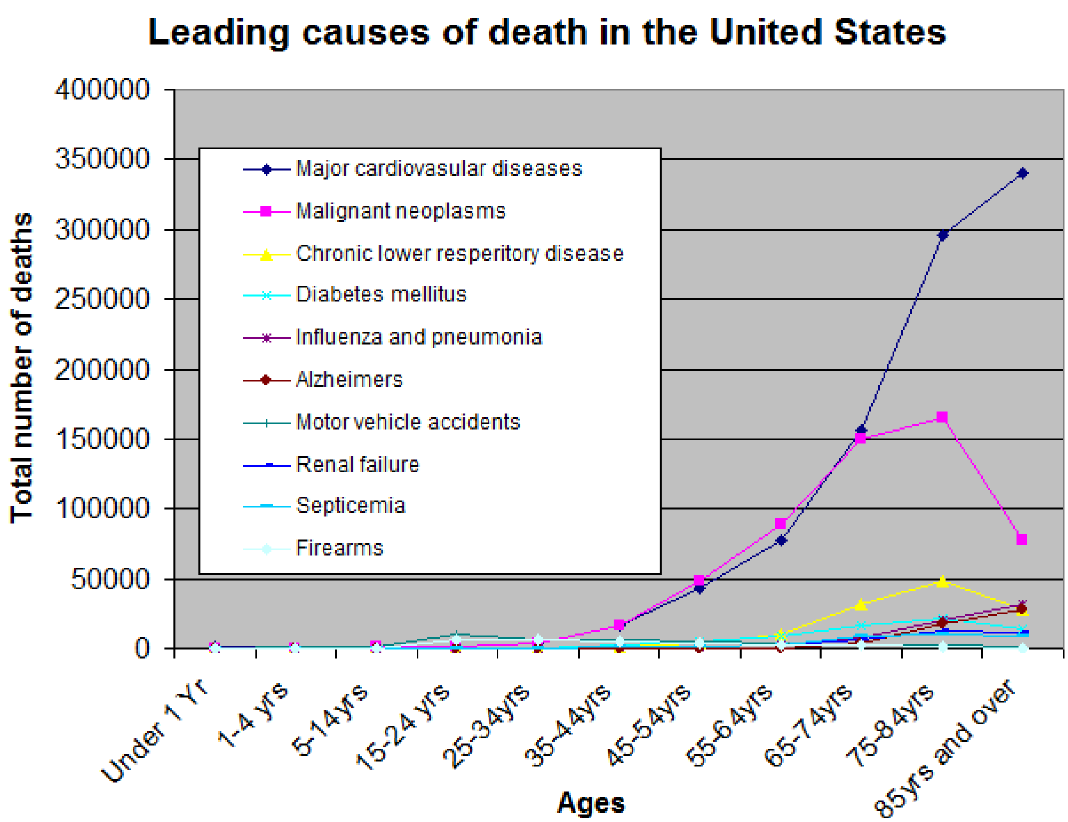


Mechanism of death

The process that causes one or more vital organs or organ systems to fail when a fatal disease, injury, abnormality or chemical insult occurs; it is the functional (physiologic) or structural change that makes life no longer possible.

Examples

Haemorrhage, hypovolemic shock, acidosis, alkalosis, asystole, ventricular fibrillation, respiratory depression and paralysis…



Questions

1. What are the five manner of death categories?

2. How would you define 'cause of death'?

Exercises

3. Describe the manner and mechanism of death in the following examples:

there are multiple correct answers

   a. A person has died of a heart attack at the age of 76:
      Manner - Cause-
   b. A person is shot and the femoral artery is severed by the bullet:
      Manner - Cause-
   c. A person is terminally ill with cancer and overdoses on morphine pills:
      Manner - Cause-

References:
Images:
http://justice.alberta.ca/programs_services/fatality/ocme/PublishingImages/caseload_statistics_manner_2000.gif, viewed 4/2009
http://medical-dictionary.thefreedictionary.com/mechanism+of+death, viewed 4/2009
http://upload.wikimedia.org/wikipedia/commons/a/a5/Causes_of_death_by_age_group_(percent).png, viewed 4/2009

Webpages:
http://australianmuseum.net.au/interactive-tools/autopsy/

Entomology: From Maggots to Murder

How are 'bugs' used to identify the post mortem index (PMI) of remains?

Why?

An important part of Forensic Entomology is the collection, identification, and analysis of insects, and often beetles, that are found on a decomposing body. The usage of insects and their larva to determine the post mortem index is what is considered the medico legal usage of entomology. An alternative is to use the study of insects in the analysis of urban pests and stored product insects that are commonly found in foodstuffs.

Learning Outcome

- Students will be able to identify the flies, maggots, and pupa most often used in the determination of PMI
- Students will be able to read an isomeglan graph or chart to determine PMI
- Students will be able to infer the effects of temperature and various abiotic factors on the growth cycle of the common flies and beetles

New Concepts

The life cycle of a fly or beetle is known and easily predictable, even with varying factors such as temperature, moisture, and sun.

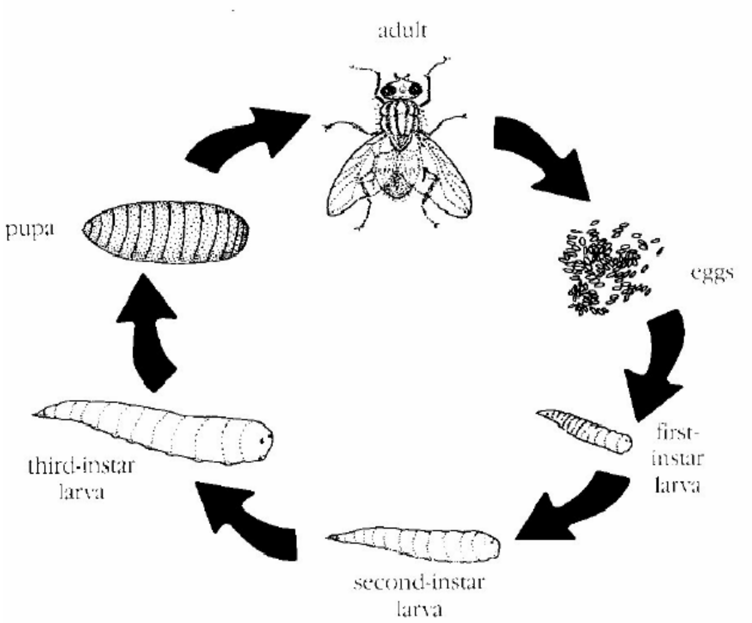
The measurement of maggots and pupa found at the body, as well as an isomeglan chart, can help determine the post mortem index of the deceased.

Prerequisites

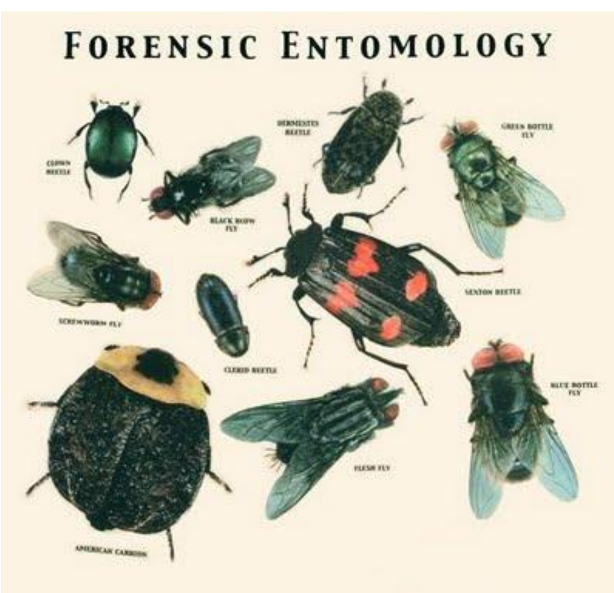
-

Reading Assignment

Model 1: The Life Cycle and Isomeglan Chart



- Each stage requires a certain amount of time
- Time to complete a stage is temperature dependent.
- At warmer temperatures the rate of development is fast, at cool temperatures it slows down
- Each species has a certain developmental rate at any given temperature



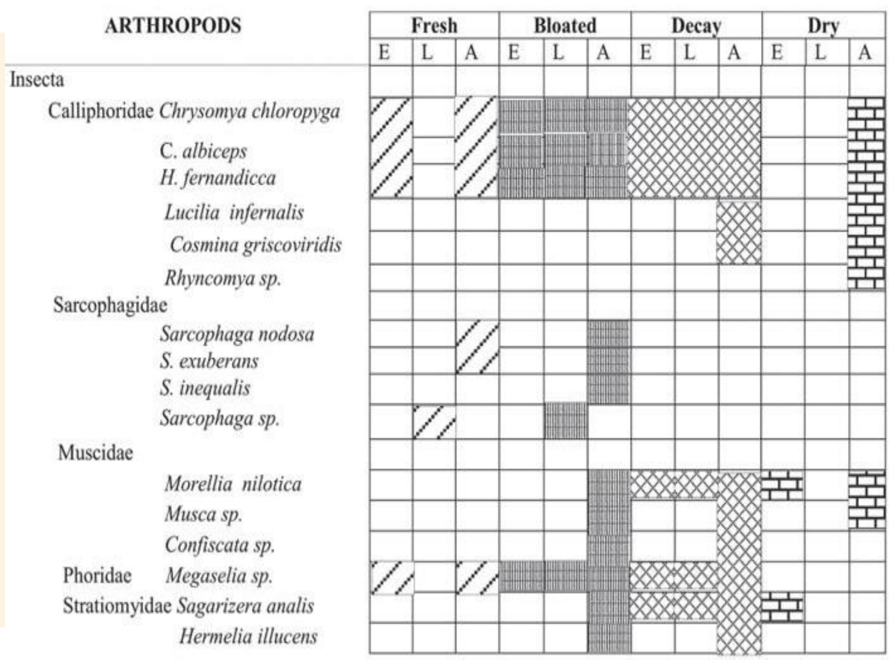
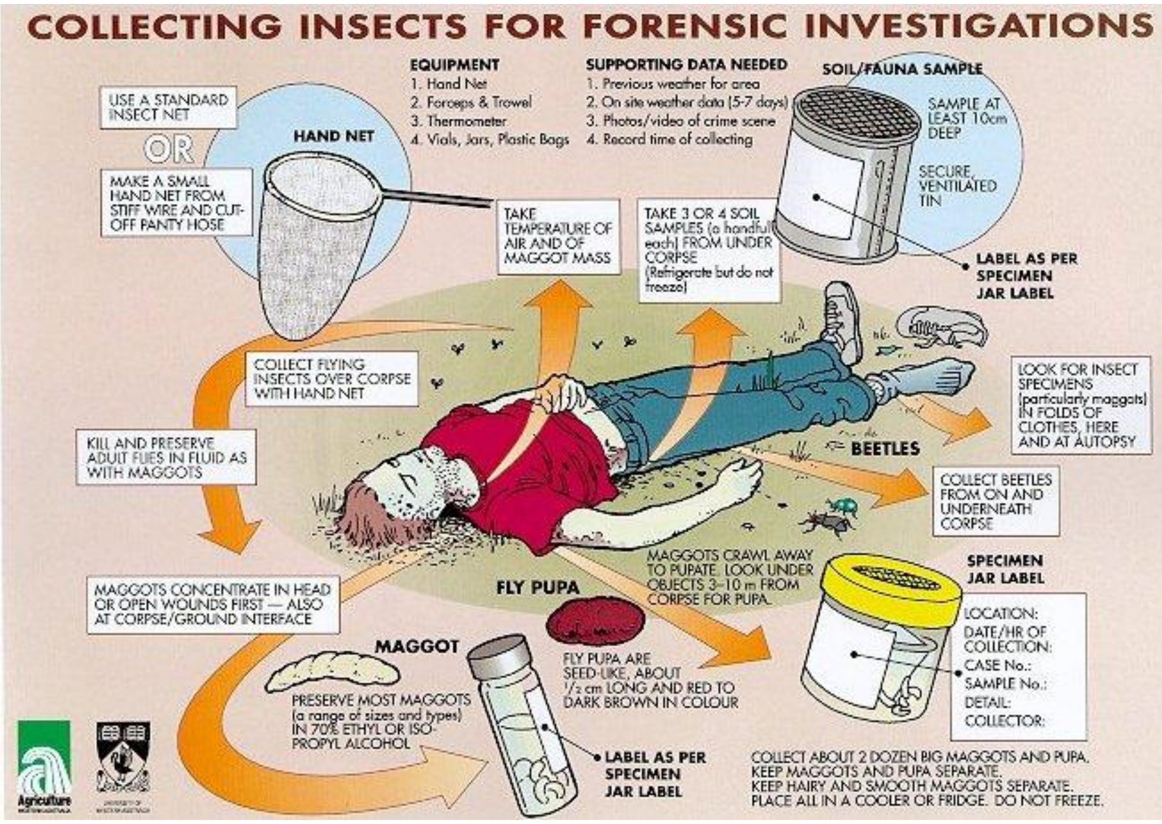
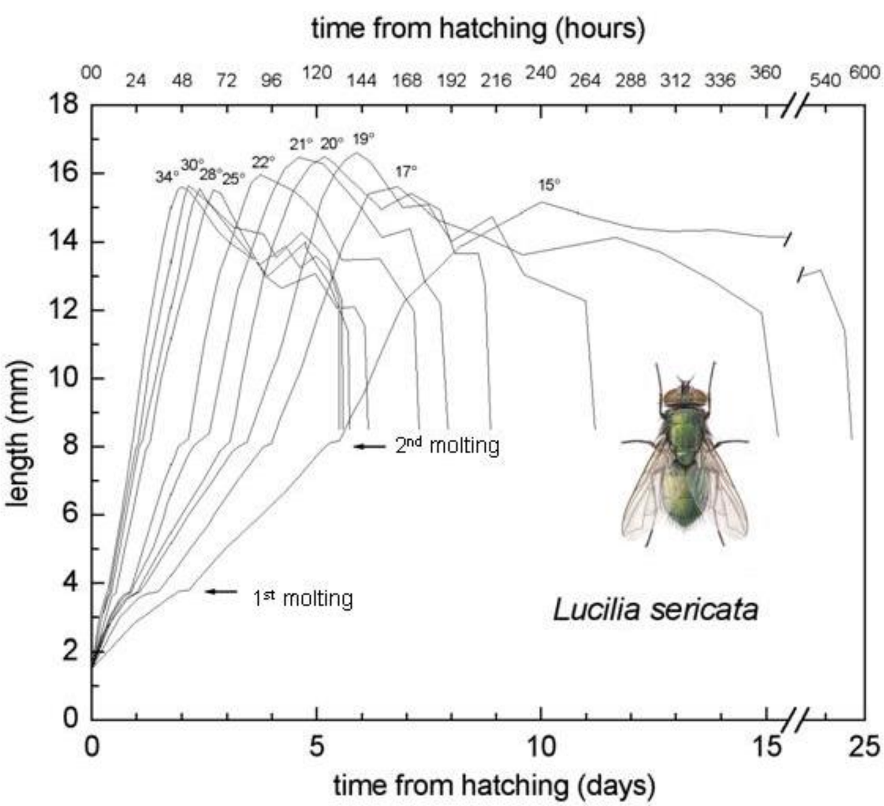


FIGURE 2: Succession pattern of the breeding arthropods on decomposing pig carcasses in Akwa Ibom, Nigeria. E = eggs, L = larval instars and pupae, A = adults.





Grassberger M. & Reiter C. (For. Sci. Int. 2001)

Questions

1. Look up and identify which flies will normally appear on a body first…

2. Describe what needs to be collected from the body to perform an entomological study:

3. When reading an isomeglan chart, what needs to be considered?

Exercises :

4. If eggs, larva, and pupa of the same species of fly are present, how many life cycles should we be looking for on the chart?

5. What would you do if you couldn't find an adequate isomeglan chart?

Use the isomeglan table provided on the next page to determine the PMI for the victim and answer a few questions about the observations you should be able to make…

Scenario 1

'Larva' found on body at scene	
Color	Length
Blue	28.7
Blue	29.1
Blue	28.5
Blue	29.0
Blue	20.1
Blue	19.9
Blue	20.2
Blue	19.5
Yellow	28.6
Yellow	29.4
Yellow	29.1
Yellow	29.0
Yellow	25.0
Yellow	24.8
Yellow	25.2
Yellow	24.6
White	28.7
White	29.1
White	28.5
White	29.0
Pink	8.9
Pink	9.2
Pink	8.5
Pink	8.6
Brown	38.5
Brown	39.0
Brown	39.1
Brown	38.7

No eggs are collected, Larva is color coded based on species and should match to an L on the chart. Pupa are brown, are not species specific, and the size will tell you the species, look for the P

…the body of a fully dressed young female has been found at 0118 in an alley behind the dumpsters in Smithville, UT… the victim is deceased with no apparent wounds on the body… the body was removed from the scene by ME Meeks at 0402 and entomological evidence has been recovered to derive PMI… No reports of a missing person matching this description at this time… Daytime temperatures have been fairly consistent for the past three weeks, ranging from 70°-74°F, no inclement weather patterns on the books…

Murder Investigation 1

1. Approximately how long has this person been dead?

2. Why are maggots of different ages found in the body?

3. Besides temperature, what abiotic conditions would you want to obtain from the weather stations to help you to be more confident of your estimation above?

4. Does the location of the body, coupled with the insects recovered from it, suggest foul play or not, or can you tell from the information given? Explain.

Table 2.
The development of body length (in millimeters) of some fly species during their metamorphosis at 72° F (L = Larva, P = Pupa, A = Adult fly).

	SPECIES			
Days after death	*Musca domestica*	*Calliphora vomitoria*	*Sarcophaga carnaria*	*Piophila nigriceps*
1		Egg	L 9-11	
2	Egg	L 9-11	L 12-16	
3	Egg	L 9-11	L 17-20	
4	L 6	L 12-16	L 21-25	
5	L 6	L 12-16	L 26-30	Egg
6	L 7-11	L 17-20	L 31-35	Egg
7	L 12-16	L 17-20	L 36-40	L 3
8	L 17-20	L 21-25	L 41-44	L 3
9	L 21-25	L 21-25	L 44-46	L 4-6
10	L 26-30	L 26-30	L 44-46	L 7-9
11	L 31-35	L 26-30	P 38-40	L 10-13
12	P 26-29	L 31-35	P 38-40	L 14-16
13	P 26-29	L 31-35	P 38-40	P 13-15
14	P 26-29	P 31-34	P 38-40	P 13-15
15	P 26-29	P 31-34	P 38-40	P 13-15
16	P 26-29	P 31-34	P 38-40	P 13-15
17	P 26-29	P 31-34	P 38-40	P 13-15
18	A 30-32	P 31-34	P 38-40	P 13-15
19		P 31-34	A 42-45	A 16-18
20		P 31-34		
21		A 36-38		

Color Key: White = *Sarcophaga* Blue = *Musca* Yellow = *Calliphora* Pink = *Piophila*
Brown = Pupa (can't determine the species of pupae except by size)

Table 3.
Ecological information for certain species of flies. The developmental delays/accelerations are given in # of days relative to the developmental schedule in Table 2 for 72° F.

		Musca domestica	*Calliphora vomitoria*	*Sarcophaga carnaria*	*Piophila nigriceps*
Temperature (°F)	55°	delayed 4	delayed 4.5	delayed 4	delayed 3
	65°	delayed 2	delayed 3	delayed 2	delayed 1
	80°	accelerated 1	accelerated 2	accelerated 1.5	accelerated 1
	85°	accelerated 3	accelerated 4	accelerated 3	accelerated 2
Ecological traits	Habitat	urban and rural	urban and rural	urban and rural	urban
	Lighting	full to partial sun	partial sun to shady	prefers sunny	prefers sunny
	Drugs	no effect	sensitive to effects	no effect	no effect

References:

Images:
http://www.umext.maine.edu/images/FlyLife.jpg, viewed 4/2009
http://www.itsgov.com/wp-content/uploads/2012/02/forensic-entomology.jpg, viewed 4/2009
http://www.scielo.br/img/revistas/paz/v50n35/a01fig02.jpg, viewed 4/2009
http://files.forensicmed.webnode.com/200000017-456a246645/forensicentomologyposter.jpg, viewed 4/2009
http://www.fsijournal.org/cms/attachment/926606/6750370/gr1.sml, viewed 4/2009
Webpages:
http://www.nabt.org/websites/institution/File/pdfs/american_biology_teacher/2003/065-05-0360.pdf

Medicinal Chemistry

What makes a chemical compound safe or toxic?

Why?

Forensic Toxicology deals with both how drugs and poisons both act upon our bodies and how our bodies respond and act upon the foreign chemical…
Forensic toxicology is the use of toxicology and other disciplines such as analytical chemistry, pharmacology and clinical chemistry to aid medical or legal investigation of death, poisoning, and drug use. The primary concern for forensic toxicology is not the legal outcome of the toxicological investigation or the technology utilised, but rather the obtaining and interpreting of the results. A toxicological analysis can be done to various kinds of samples. A forensic toxicologist must consider the context of an investigation, in particular any physical symptoms recorded, and any evidence collected at a crime scene that may narrow the search, such as pill bottles, powders, trace residue, and any available chemicals. Provided with this information and samples with which to work, the forensic toxicologist must determine which toxic substances are present, in what concentrations, and the probable effect of those chemicals on the person..

Learning Outcome

- Students will be able to identify the difference between a drug and a poison
- Students will be able to identify such toxicology terms as LD_{50}, MSDS, acute toxicity, and chronic toxicity
- Students will be able to identify the CSA and the five classes of drugs, as well as what each drug class does to the human system

New Concepts

There are differences between drug use and drug abuse, differences based on dosage and other contributing factors

There is a difference between pharmacokinetics and pharmacodynamics

There are three distinct mechanisms identified as the creating of new drugs

Prerequisites

- none

Reading Assignment

Saferstein, 8^{th} edition, pg. 1-22

Model 1 : Toxicology Vocabulary :

http://www.abft.org/files/WHAT%20IS%20FORENSIC%20TOXICOLOGY.pdf

*Use the provided link to access an informational brochure about forensic toxicology.

1. What does a toxicologist do?

2. When working with a medical examiner or coroner, what role does a toxicologist play:

3. What is Human Performance Toxicology?

4. When is Workplace Drug Testing done?

Problems

5. Should evidence be accepted into the court room under the Frye Standard?

6. What is meant by LD_{50}:

7. Define the following:

Acute toxicity:

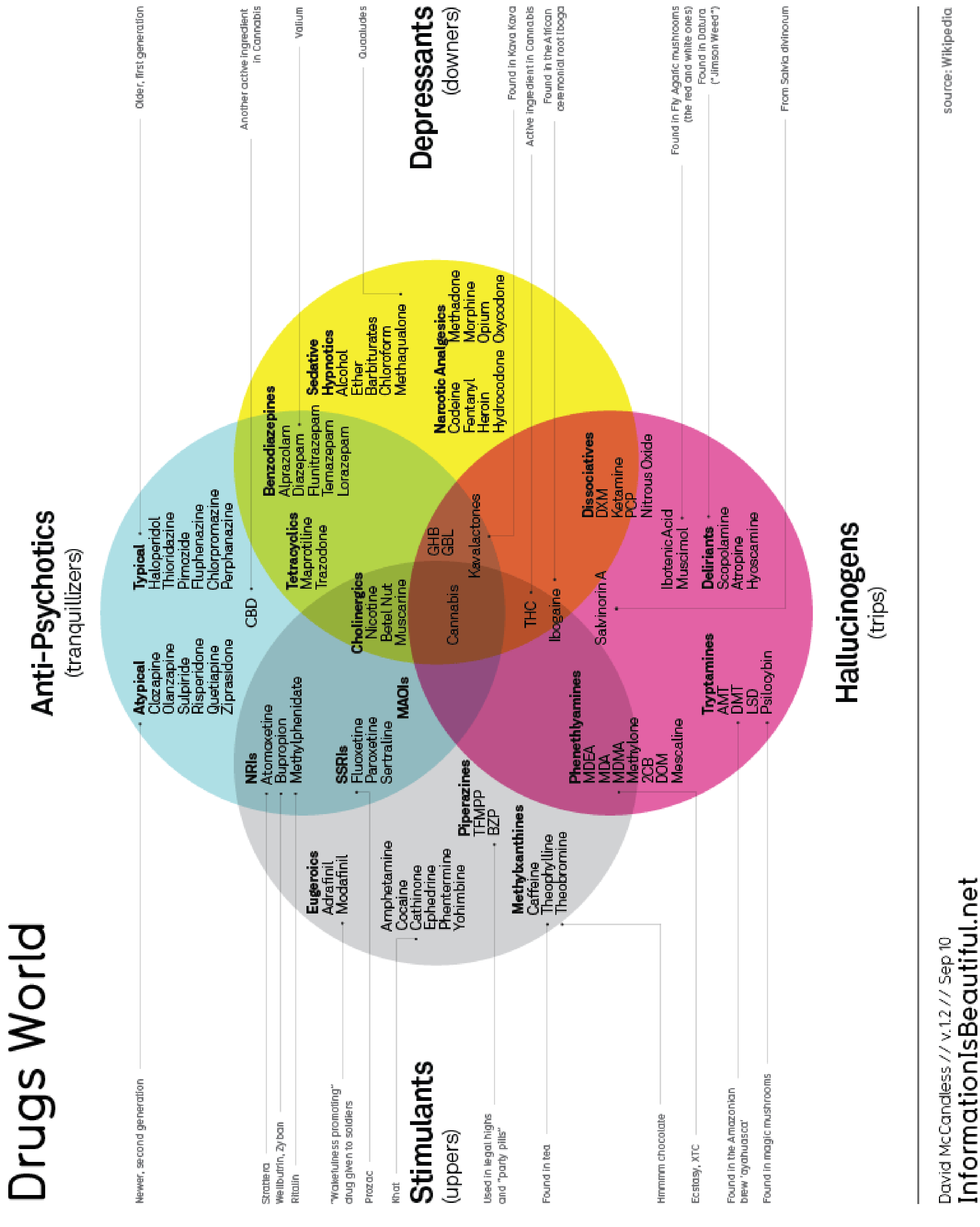
Chronic toxicity:

Sensitization:

Tolerance:

Bioaccumulation:

Model 2 : Controlled Substance Act & Classification of Drugs



	Schedule I	Schedule II	Schedule III	Schedule IV	Schedule V
Potential for abuse	The drug or other substance has a high potential for abuse	The drug or other substance has a high potential for abuse	The drug or other substance has a potential for abuse less than the drugs or other substances in schedules I and II	The drug or other substance has a low potential for abuse relative to the drugs or other substances in schedule III	The drug or other substance has a low potential for abuse relative to the drugs or other substances in schedule IV
Medical use	The drug or other substance has no currently accepted medical use in treatment in the United States	The drug or other substance has a currently accepted medical use in treatment in the United States or a currently accepted medical use with severe restrictions	The drug or other substance has a currently accepted medical use in treatment in the United States	The drug or other substance has a currently accepted medical use in treatment in the United States	The drug or other substance has a currently accepted medical use in treatment in the United States
Consequences of abuse	There is a lack of accepted safety for use of the drug or other substance under medical supervision	Abuse of the drug or other substance may lead to severe psychological of physical dependence	Abuse of the drug or other substance may lead to moderate or low physical dependence or high psychological dependence	Abuse of the drug or other substance may lead to limited physical dependence or psychological dependence relative to the drugs or other substances in schedule III	Abuse of the drug or other substance may lead to limited physical dependence or psychological dependence relative to the drugs or other substances in schedule IV

Questions

8. The Controlled Substance Act established five schedules of classification for substances based on what three things?

9. Fill in the following chart

Drug Type	Effects on the Human Body	Example of this drug type
a) Narcotics		
b) Depressants		
c) Stimulants		
d) Hallucinogens		
e) Club Drugs:		
f) Steroids		

Exercises

10. How are new medicinal drugs discovered? (List all lecture identified methods)

11. What is the difference between a presumptive and confirmatory drug testing?

12. What does gastric emptying have to do with the consumption of alcohol?

13. A breath test reflects the alcohol concentration in the **_________** and is an example of this type of analytical technique:

References:
Images –
https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcR56pai4tS3K8CrSjOmnwPiZSaUa5-SyyNJKHRtBtGlZRTKqGSUpg, viewed 12/2010
http://www.educatedearth.net/media/82/drugchart.gif, viewed 12/2010

Websites-
http://www.abft.org/files/WHAT%20IS%20FORENSIC%20TOXICOLOGY.pdf, viewed 12/2010

Science vs. Pseudo Science

What is the difference between ‘real’ science and ‘pseudo’ science?

Why?

The analysis of pieces of evidence is an imperative part of bringing evidence into the courtroom. The science behind the evidence is equally, if not more, important than the evidence. If the science behind the analysis has not been accepted by the scientific community, the evidence may not be accepted into court. New scientific procedures must be proven before acceptance in the courtroom.

Learning Outcome

- Students will be able to identify the components necessary for ‘real’ science.
- Students will be able to perform basic statistical analyses.
- Students will be able to distinguish between the types of microscopes utilized during the analyses of prominent physical and biological evidence gathered at the crime scene will emphasizing the science of microscopy as a true science.

New Concepts

Certain tests recognizable to the public or not accepted in the courtroom due to the lack of scientific evidence needed to back up the analysis.

The use of microscopy has come under fire during the consideration of certain types of physical evidence. Examination of the science behind microscopy will allow the students to decide for if the science can be considered viable.

Prerequisites

- Scientific Method

Reading Assignment

Model 1: Pseudoscience Activity

In this activity, you will be determining the accuracy of Horoscopes. You will attempt to match your own sign from a variety of unidentified signs collected from a horoscope column. These predictions were for Sunday, January 27th, so think back to Sunday and choose the horoscope that best matches how your day went…

List your birthday:________________________________

List your horoscope sign: ______________________________

Use the following table if you are unsure of what your sign is supposed to be:

Aries (3/21-4/19)	Libra (9/23-10/22)
Taurus (4/20-5/20)	Scorpio (10/23-11/21)
Gemini (5/21-6/21)	Sagittarius (11/22-12/21)
Cancer (6/22-7/22)	Capricorn (12/22-1/19)
Leo (7/23-8/22)	Aquarius (1/20-2/18)
Virgo (8/23-9/22)	Pisces (2/19-3/20)

The following horoscopes have been mixed up and numbered from 1 to 12. Read through the horoscopes and select the paragraph that best predicted your day TODAY…

Identify the number of the matching horoscope here:

1. New beginnings aren't just your sign's specialty, they're your very favorite state of affairs too. Happily, that's exactly what's on the agenda right now, thanks to an impending career offer that can only be called sweet. It may be so sweet, in fact, that you'll be tempted to jump on it right away. Moving quickly might not be a bad idea, but taking time to check out the details first via a trusted, knowledgeable friend can't hurt. Give them a call.

2. You're happy with yourself. You always have been, and there's no reason to think that you won't continue to be. You have, however, been thinking about introducing a new and improved you to the world. The thing is, you'll have to create this person before you throw his or her coming out party. That's the easy part. Believe it or not, it's deciding when to do it that takes the real work.

3. You're due for the type of experience that includes the urge to take yourself somewhere you've never been. If you have a spontaneous travel companion who's prodding you, that urge may be especially irresistible. Oh, well. Put your nose to the grindstone and spend the evening immersed in a pile of brochures and maps -- for a future time.

4. You've always been known as a private person. That's the way you were born and the way you'll always be. So when someone approaches you with a smirk and a not-so-subtle question about what you have up your sleeve at the moment, don't feel obligated to let them in on your secret -- and make sure you know that's how you feel.

5. Nothing short of intense, meaningful conversation will do at the moment, and anyone who deliberately tries to avoid the issue via pointless, trivial chitchat will receive their just desserts: A chilly stare and a fleeting glimpse of the back of your head. By the same token, if you've been deliberately avoiding a topic your sweetheart has tried to bring up for weeks, you'll change your tune in a hurry. You may even wish they'd let it slide just a little bit longer.

6. Your chance to turn one of your dreams into a goal and tackle that goal with your usual meticulous attention has now officially arrived -- and if you're dealing with the department of long-distance travel, higher education or spiritual quests, you'll have all the heavenly help you could ever ask for to get the show on the road. Go for it.

7. Your sign's skills as negotiator, mediator and go-between have been famous for what seems like forever, and with good reason. You can talk anyone into anything, so long as you believe in your heart that it's the right thing to do. So when you're approached by someone who needs you to help them deliver the unvarnished truth, you won't just accept the job -- you'll volunteer for it. And well you should.

8. After days of heavy, intense conversations, you've finally reached a compromise of sorts. You'll keep talking, but there will be absolutely no arguing. If you can't see eye to eye, you'll agree to disagree. Initially, that might not sound like progress. But if you think of where you've come from, you'll realize that it's not just progress -- it's the beginning of a whole new style of communication, and it will lead to a whole new type of understanding.

9. Every picture tells a story, so go ahead and dig out those old snapshots of you and that long-lost someone you haven't talked to in forever. Wow -- look how much fun you guys had together! Isn't it a shame you drifted apart and lost touch? Wouldn't it be great to get in contact and see how they're doing now? And isn't it funny that these are all questions you can answer?

10. Fasten your seatbelt and put your tray table in its upright position. You're about to take flight -- and that applies to every possible corner of your life, but most especially to affairs of the heart. So if you've been seeing someone casually, that won't be the case any longer. One or both of you will either want to make a commitment or say your goodbyes. But don't worry; the heavens are chock full of romance, and betting on anything other than commitment just wouldn't be prudent.

11. Sometimes your fantasies are like scenes out of a science fiction movie and seem to have little basis in reality. Now, however, your dreams can hold the key to your immediate future because your imagination is being fed directly by your everyday experiences. Don't try to rein in your thoughts; patiently let them wander as they will. Paying attention to the messages from your subconscious just might lead you to a wonderfully useful treasure.

12. You might be so positive about what comes next that you find yourself defending your plans against someone at work today. It may feel as if others are being overly aggressive, but it's more likely that you don't want to face any negativity at all. Don't avoid the facts just because

it makes sticking to your strategy easier to justify. It's crucial to acknowledge any errors in judgment as soon as possible any apologize if necessary. If you have missed something important, modify your strategy and get back to work.

The true horoscope list will be provided for you on the Projector during class at which time you will find your real horoscope and identify whether you accurately chose your sign:

Questions

1. What percentage of the class do you believe has accurately chosen their horoscope sign? List as a percentage between 0 – 100:

2. What percentage of the class actually chose their horoscope sign? List as a percentage between 0 – 100:

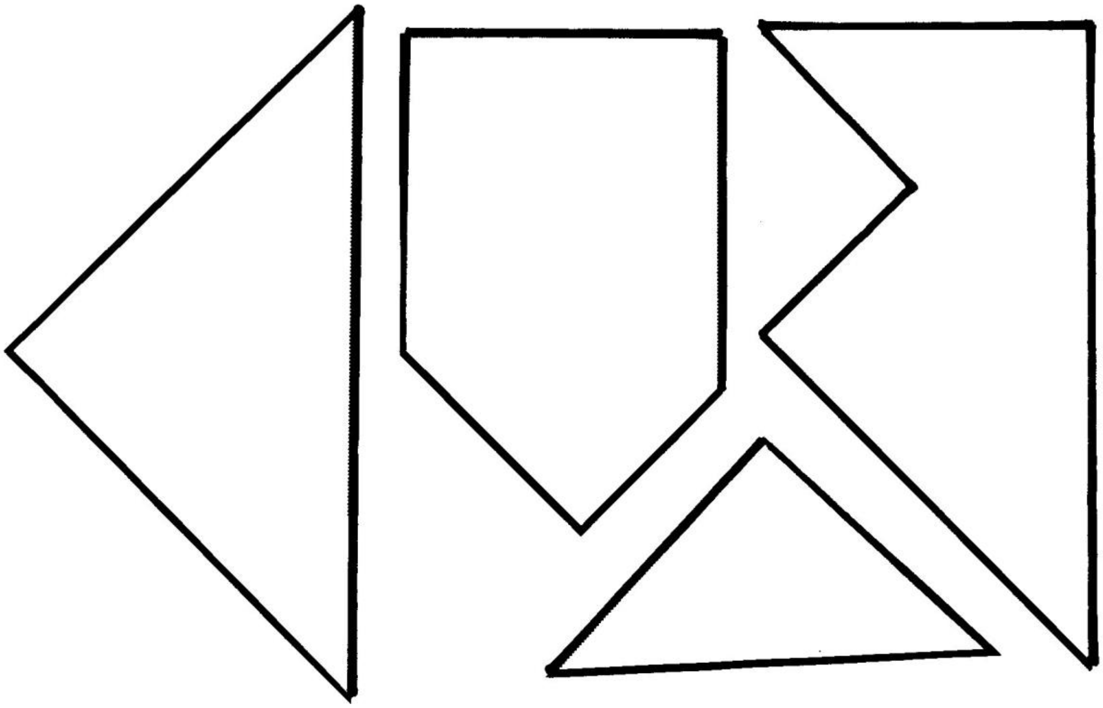
3. If Sun sign astrology can predicts a person's day accurately, and everyone remembers the day in question clearly (the astrologer's hypothesis), students should in general be able to find their own paragraph. But if chance instead of the stars governs the composition of those descriptions (the skeptic's hypothesis), we would expect that only one out of 12 of the students would have selected the description for their own signs.
   Which have we substantiated, the astrologer or the skeptic? Explain your answer:

Exercises

4. Provide a list of other ideologies that are questionable as a science, and give an explanation as to why they are questionable:

5. Would any of the above ideologies be applicable in the courtroom? Why or why not?

Model 2 : Science Activity



The above four pieces of evidence have been provided for you. Cut them out and attempt to fit them into a perfect square, presuming the square is the solution to the crime…

Questions

1. Approximately how long did it take you or your group to solve the scientific puzzle? Did you solve the puzzle ahead of time and take control and demonstrate the correct answer?

2. How did the first phase of the activity represent current scientific inquiry?

3. How did the second phase of the activity represent current scientific inquiry?

3. If you are a judge, acting as 'gatekeeper', what will you need to consider in order to determine if the evidence being presented is scientifically sound?

Exercises

6. From previous discussions in class, define what a class characteristic is, and list an example:

7. From previous discussions in class, define what an individual characteristic is, and list an example:

8. How has science changed the use of class characteristics vs. individual characteristics in the courtroom? Explain your answer and give at least two examples to support your group discussion::

Problems

3. Looking at the given pictures from a crime scene, identify the individual and class characteristics that can be determined and identify the scientific method/apparatus that you believe will be needed to analyze it::

Model 3 : Statistics: THIS MODEL IS PREP FOR THIS WEEK's LAB

Statistical Analysis:

Measures of Central Tendencies: give information about the average, or typical, data point, when a large grouping of data is considered:

Mean: the calculated average – sum of all data points dived by the number of data points collected…

Median: the data set that sits in the middle when data is placed in numerical order…

Mode: the data point that appears the most times in the data set

Measures of Variability: gives information about the data as a collective set

Range: based on only two scores, the highest and the lowest, listed as a single value and is the difference between the high and low data points…

Standard Deviation: takes into account all the scores in the data set and indicates how much one score deviates from another… You need to square every data point and add them all together to find the numerator, while the denominator is simply the number of data points collected. Once the quotient is determined, subtract the mean squared from it and then the square root is taken

Equation for Standard Deviation

$$SD\ (\sigma) = \sqrt{\frac{\sum (x-\overline{x})^2}{n}} \quad \text{(eqn. 3.2.1)}$$

[where **x** is the value of a data point, $\overline{x}$ is the mean, **Σ** is the sum for all of the data points, and n is the number of data points]

Variance: identifies an overall change found among the data set, and is simply the standard deviation squared….

Probability

The probability of a particular event occurring is easily calculated. The number of ways that particular event can occur divided by the total number of possible outcomes, will give you the probability. If you're looking to combine events, two methods are advised. If your look for one event OR a different event, calculate the probabilities separately and then ADD them together. If you're looking to have one event AND a second event occur, calculate the probabilities separately and then MULTIPLY them together.

Questions

1. What is the difference between precision and accuracy?

   Accuracy:

   Precision:

4. Identify the three ways to evaluate Central Tendencies:

5. Identify the three ways to evaluate Variability:

6. Identify the two different ways you need to calculate probability:

Exercises

7. Knowing that 1 inch is equivalent to 2.54 cm, convert the following two measurements: (2 points)

   a. a person stands 67.3 inches tall, how tall is she in cm ?

   b. Professor Meeks has run several 15K race in Utica, how many inches are in a 15K (1.5 $x10^6$ cm)?

6. Identify the mean, median, mode, and range for the following problem:

A set of bullet straie are compared to a standard, and the following are the numbers of lines that are found to be matching:

58, 62, 49, 52, 53, 58, 61, 50, 63, 59

mean:

median:

mode:

range:

Calculate the standard deviation and variability for the data set:

standard deviation:

variability:

7. A victim is found with a carpet fiber dried in blood under the fingernails of her right hand. The carpet fiber could be from a car, an industrial area, or a residential area. The most common colors of carpet are blue, brown, medium tan, and ivory. The carpet fiber could be polyester, PPE, or acrylic. What is the probability that the fiber found under the victims nail is from the suspect's blue acrylic carpet in his car?

THIS TABLE MAY BE USEFUL FOR ORGANIZING THURSDAY'S LECTURE

Model 4 : Microscopes

Type of Microscopy	What makes this microscopy unique?	Examples for use in Forensics:
Compound Microscope		
Comparison Microscope		
Stereoscope		
Phase contrast microscope / Dark Field microscope		
Polarizing Microscope		
Fluoroscopy		
Electron Microscopy		

References:
http://www.scienceteacherprogram.org/genscience/Choi04.html
http://www.thefreelibrary.com/Using+the+psychic+blue+dot+to+teach+about+science+(and+pseudoscience).-a0193791694

Images :
http://www.google.com/imgres?imgurl=http://www.leelofland.com/wordpress/wp-content/uploads/2008/02/me-crime-scene.jpg&imgrefurl=http://qwickstep.com/search/crime-scene-evidence.html&usg=__mqAIW21au-RHqjoZDGzfiSaNx4A=&h=336&w=448&sz=49&hl=en&start=0&sig2=kfo0PItXGt3KL-FhuALpbg&zoom=1&tbnid=oLF4AsaqH-MA-M:&tbnh=159&tbnw=210&ei=-z1HTdCoMoP88Ab8-tS0AQ&prev=/images%3Fq%3Dcrime%2Bscene%2Bevidence%26um%3D1%26hl%3Den%26sa%3DN%26rlz%3D1W1ADRA_en%26biw%3D1291%26bih%3D495%26tbs%3Disch:1&um=1&itbs=1&iact=hc&vpx=794&vpy=124&dur=4540&hovh=194&hovw=259&tx=103&ty=216&oei=-z1HTdCoMoP88Ab8-tS0AQ&esq=1&page=1&ndsp=11&ved=1t:429,r:4,s:0

Skulls, Hips, and Femurs

How are bones used to identify the gender, age, physical attributes, or ancestry of remains?

Why?

An important part of Forensic Anthropology is the creation of a biological profile of remains uncovered, or discovered. Upon the determination of the remains being human, a set of procedures can be followed to build a biological profile of the person whose remains have been found. Components of that biological profile include gender, age, physical attributes, and/or ancestry. These determinations can be made from a combination of certain bones in the skeleton, primarily the skull, hip, and femur.

Learning Outcome

- Students will be able to identify the information most often included in a biological profile.
- Students will be able to identify which bones are best suited to particular biological determinations.
- Students will be able to make the determinations of gender, age, physical attributes, and ancestry using the skull, hip, and femur supplied.

New Concepts

The skull is most often utilized to determine the gender, age, and/or ancestry of human remains.

The hip is utilized to determine gender and possible age of remains.

One of the physical attributes that can be calculated from remains is the stature of the individual during life based upon measurements taken from the long bone.

Prerequisites

- Human skeletal vocabulary

Reading Assignment

Model 1 : The Biological Profile

The forensic anthropologist's examination begins by asking, and answering, the following questions:

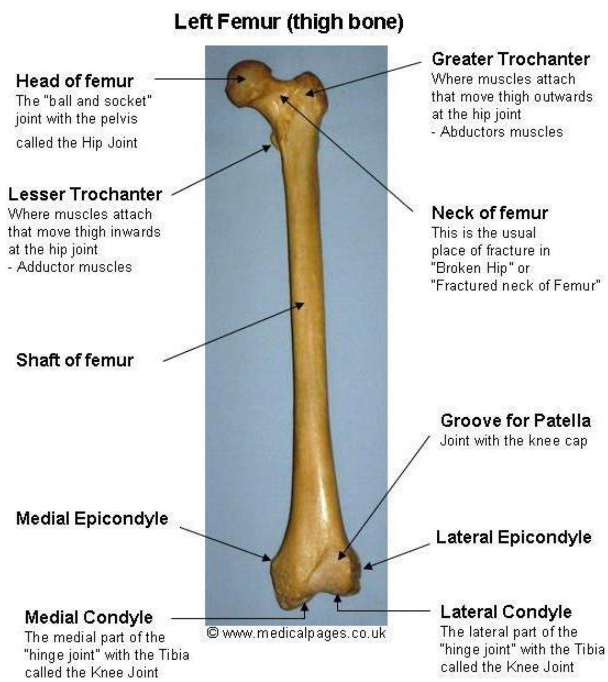
What is the individual's racial affiliation?

What is the individual's age and stature?

Is there any evidence of trauma or foul play at or near the time of death?

Are there any distinguishing skeletal traits that may aid in establishing the identity?

Is there any indication of post-mortem treatment or alteration of the remains?



Racial Affiliation

The determination of the racial ancestry of a recovered skeleton is especially difficult. Although racial classification has some biological components, it is based primarily on social affiliation. When looking for anatomical details that will point the anthropologist in the right direction, they look to the skull, especially the face.

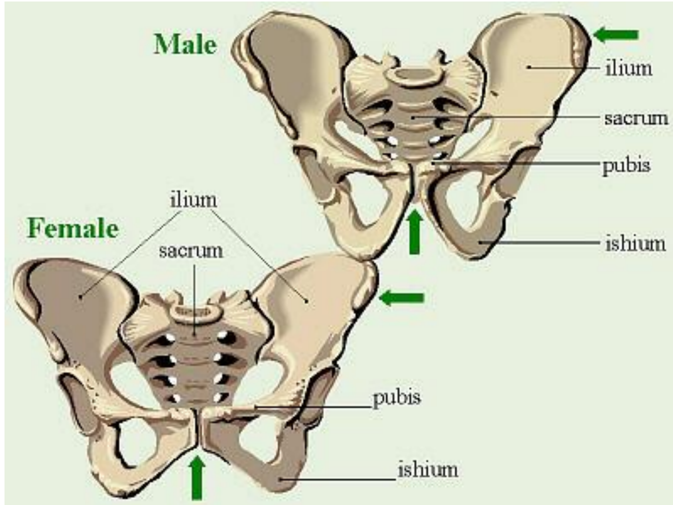
Age and Stature

The age of the 'victim' can be determined by examining biological traits that are predictable to certain ages. The exact age is not established, a range of potential ages is. Usually, examination of the pubic bone, sacroiliac joint, amount of dental wear, cranium, arthritic changes in the spine, and microscopic studies of bones and teeth narrows the age range estimate that will be given.

The stature of an individual can be calculated by measuring any of the long bones present. Once the measurement is taken a formula is applied and a narrow range for the height of the individual can be estimated. The formula is based on the sex of the individual, so that must also be determined before continuing.

Gender

The gender of the victim is most often determined using the pubic bone of the remains. The pubic bone has a variety of points to consider to make the determination. A forensic anthropologist will examine the pelvis as a whole, the brim, the body of the pubis, the sub-pubic arch, the greater sciatic notch, the sacro iliac joint, and the sacrum.



Time Interval Since Death

Post mortem index can be estimated, with difficulty, by examining the condition of any soft tissue that may be present. This estimation is contingent on many different factors, including the preservation of the bones, extent of associated plant root growth, odor, and any carnivore and insect activity. Extraneous conditions must also be considered: temperature of environment, penetrating wounds, humidity/aridity surrounding the body, soil acidity, burial versus exposure of bones, and water retention. The longer the time since death, the more difficult it is to determine the post mortem index.

Questions

1. What does a biological profile consist of?

2. Which bone(s) is most useful for analyzing the racial affiliation of the decedent? What do you look for?

3. Which bone(s) is most useful for analyzing the age of the decedent? What do you look for?

4. Which bone(s) is most useful for analyzing the stature of the decedent? What do you look for?

5. Which bone(s) is most useful for analyzing the gender of the decedent? What do you look for?
6. What are some distinguishing skeletal traits that may aid in establishing the identity?

Exercises

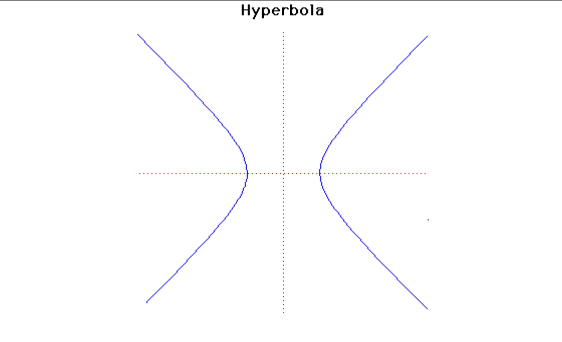
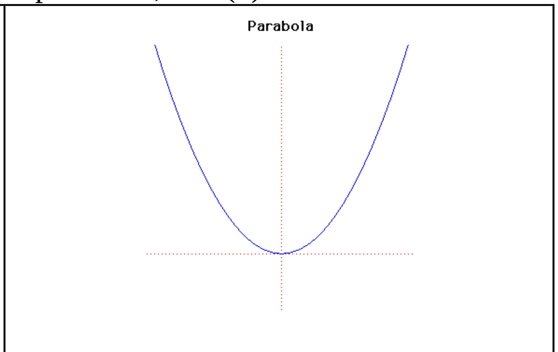
I. Racial Affiliation:

Procedure:

(3) A skull has been brought to class and the maxillary bone is being projected to the center screen. Determine which of the following shapes best describes the maxillary bone:

The arch of the maxilla can be found in three basic shapes: hyperbolic, parabolic, and rounded. Each of the following three races has their own shape:

(1) African = hyperbolic, (2) European = parabolic, and (3) Asian = rounded.

	
Hyperbola	Parabola
Image from http://www.gap-system.org/~history/Curves/Hyperbola.html	Image from http://www.gap-system.org/~history/Curves/Parabola.html

(4) The incisors also differ slightly in their basic shape and can help determine racial affiliation. Locate the incisors on the skull specimen. Determine which of the following shapes, from the side/inside, best describes the incisors:

The incisors fall into two basic categories, based on the shape of the lingual (tongue) surface of the tooth. Although these are not as unique as the maxillary bone, this will help you be more definitive in your assessment:

(1)Asian = shovel-shaped, and (2) African and European = spatula-shaped.

II. Age and Stature:

Procedure:

(1) Identify whether you believe the skull is from an infant, adolescent, or adult.

(2) Using the femur projected to the center screen and the formula given below, calculate the stature in the metric system.

(3) Using dimensional analysis, convert this measurement to inches, and the list the height using the English system.

Bone (**See Image**)	**Formula for calculating Body Height (in cm) . . . EVERYONE!**	
	Female	***Male***
Femur	Height equals (length of femur x 1.94) + 72.9	Height equals (length of femur x 1.88) + 81.3
Humerus	Height equals (length of humerus x 2.8) + 71.4	Height equals (length of humerus x 2.9) + 70.6
Radius	Height equals (length of radius x 3.3) + 81.3	Height equals (length of radius x 3.3) + 86.4

III. Gender

Procedure:

(1) A pelvic bone has been brought to class and is being projected to the center screen. Looking for each of the following parts to the pubic bone, identify the shape or observations for that section, and determine the gender of the 'victim' when completed.

(2) Skulls can also be used to determine gender, although the determination is more subjective, and less accurate.

(3) A skull has been brought to class is being projected to the center screen.. Looking for each of the following parts to the skull, identify the shape or observations for that section, and determine the gender of the 'victim' when completed.

Landmarks	**Female**	**Male**
Chin	**Rounded**	**Square**
Mastoid Process (Behind Ear)	**Small**	**Large**
External Occipital Protuberance (Back of Skull)	**Small (Not Prominent)**	**Large (Prominent)**
General Anatomy	**Gracile (i.e., Graceful)**	**Robust**
Forehead	**Vertical**	**Receding**
Brow Ridges (Location of Eyebrows)	**Slightly Developed**	**Prominent**
Muscle Lines	**Slightly Developed**	**Prominent**
Orbital Margins (Edge of Eye Socket)	**Sharp**	**Rounded**

References:

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http://shs.westport.k12.ct.us/forensics/11-forensic_anthropology/skeletal_analysis.htm
http://www.picturenation.co.uk/result?s=skeleton
http://www.dundee.ac.uk/forensicmedicine/notes/ident.pdf
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http://biology.clc.uc.edu/graphics/bio105/pelvis.jpg

Soil, Residue and Paint

What characteristics of glass, soil samples, and paint chips are examined as evidence?

Why?

The presence of, and combinations of, compounds in glass, soils, and paint allows a forensic investigator to individual evidence found at crime scenes. Knowing the specific compounds that can be found in evidence of this nature will allow a criminalist to determine first class characteristics and then individual characteristics.

Learning Outcome

- Students will be able to identify the composition of glass and how to use this information to individualize glass evidence
- Students will be able to identify the composition of soil and how to use this information to individualize soil evidence.
- Students will be able to determine the components used to create paint and how to analyze paint chips that have been collected.

New Concepts

Glass is made of silicon oxide (sand) and metal oxides that are melted and then cooled. This process yields an amorphous liquid (liquid!) with no crystal structure, creating a hard, brittle surface.

Soil is a heterogeneous mixture made of both organic and inorganic materials – identifying those components can aid in the individual characteristics unique to a topographical area

Paint is made of distinct layers, each layer a component that can help identify the source of a paint chip found at a crime scene or on a body

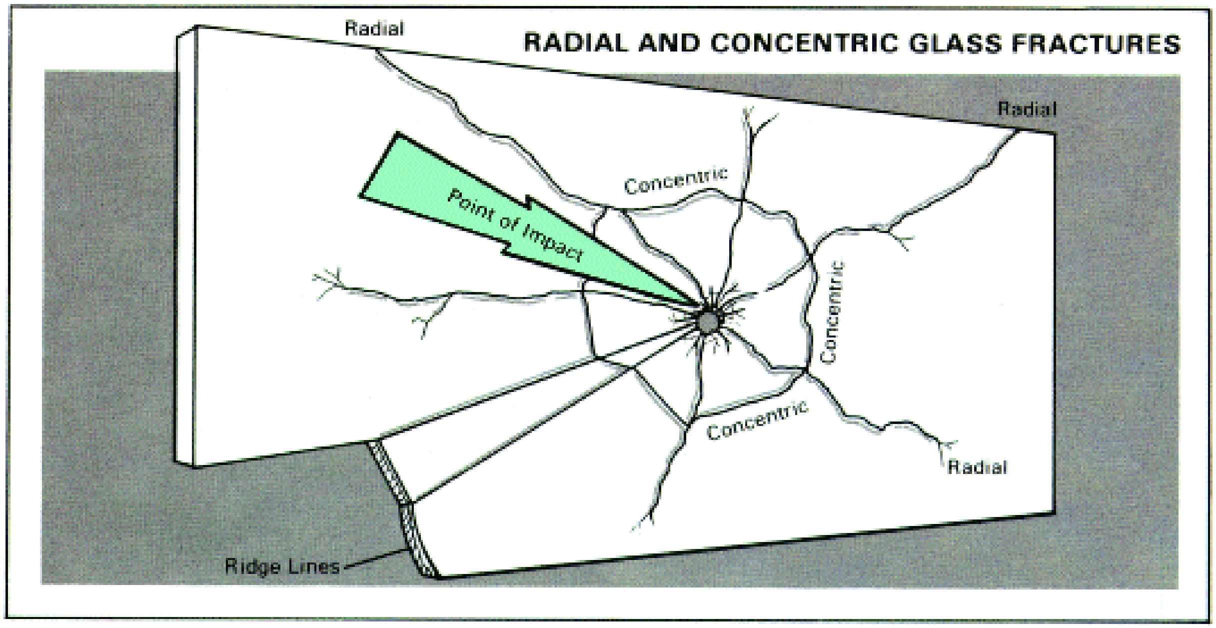
Prerequisites

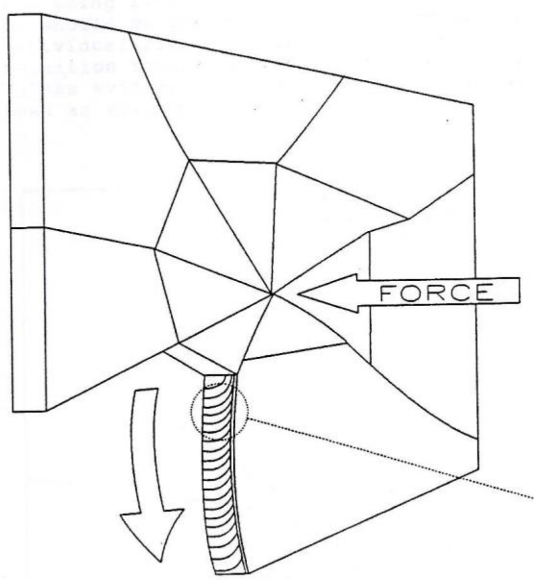
- Organic and inorganic characteristics, Homogeneous and Heterogeneous Mixtures vs. Pure Substances

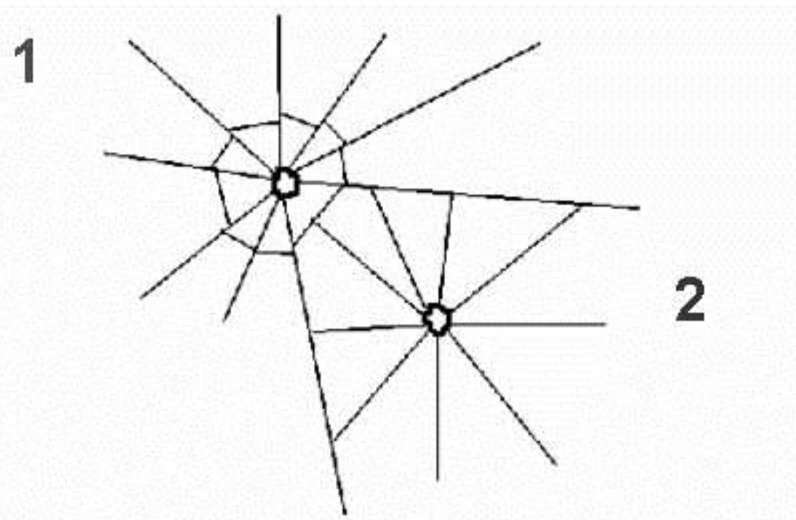
Reading Assignment

Saferstein, 8th edition, pg. 136-147

Model 1 : Glass







MULTIPLE GLASS FRACTURES - *showing radial and cross fractures, illustrates effect of first fracture in stopping cracks of second fracture.*

Questions

1. From lecture, we learned that <u>three physical properties</u> were used primarily in the analysis and comparison of glass samples. Identify and describe them:

   a.

   b.

   c.

2. When looking at a broken glass, <u>three distinct marks</u> can be identified and described:
   a.

   b.

   c.

3. How do you determine which bullet or force encounters the glass first, second, third, etc.?

Exercises

1. In lab, you can use density columns to determine the density of fragments of glass and plastic. Apply that knowledge to the following question:

   Given the following information, drawing a density gradient and show where the three samples of plastic would be…

Liquids

Bromoform ($CHBr_3$)	2.84
Clove Oil	1.038-1.060
Ethanol	0.789
o-Xylene[2]	0.870

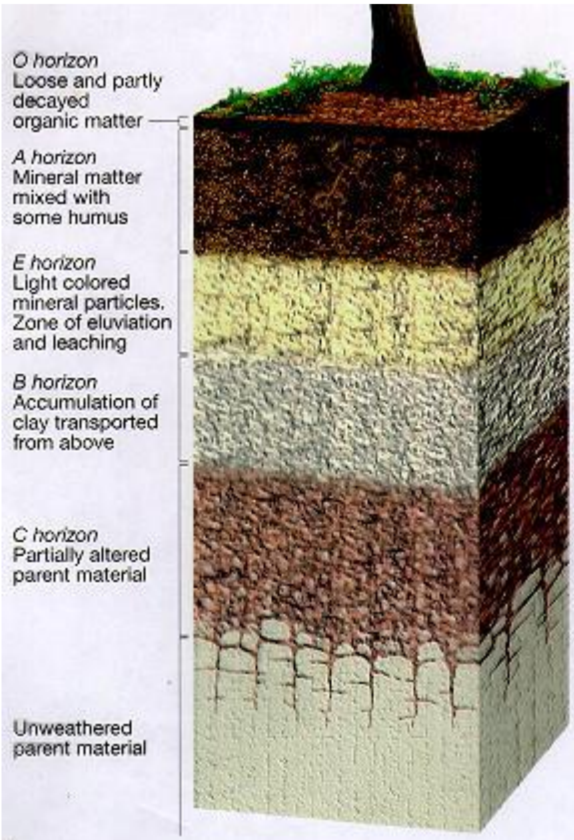
Plastics

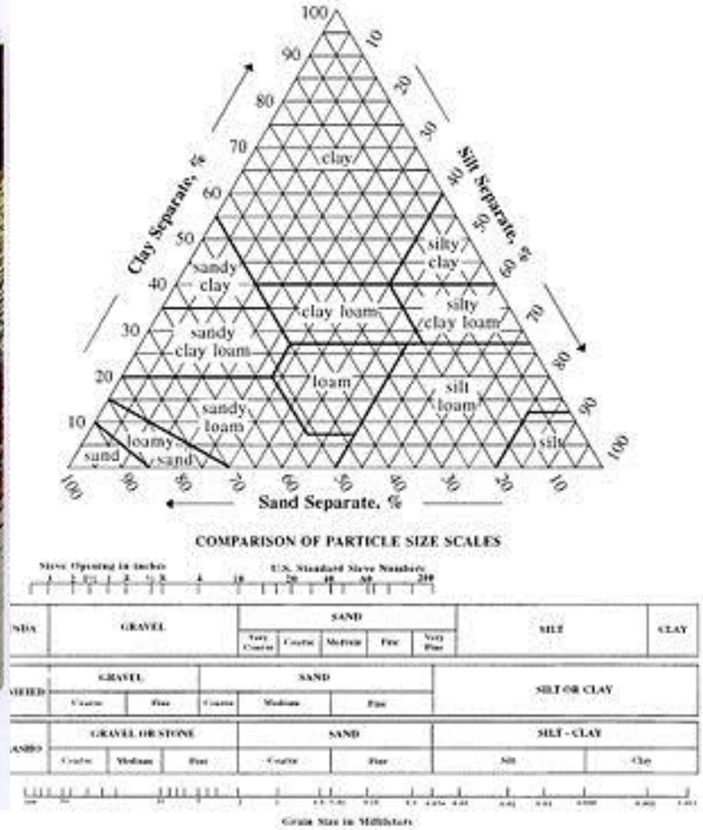
Low Density Polyethylene (LDPE, #4)	0.917 – 0.940
Polystyrene (PS, in solid form, #6)	1.04 – 1.05
Acrylonitrile Styrene (AS/SAN, #7)	1.08

2. In lab, you can use measure the density of a piece of broken glass using buoyancy. Given the following data set, calculate the density of potash glass.

Avg. Mass of sample:	3.13 g
Avg. Mass of beaker and water:	41.56 g
Mass of beaker, water, and glass sample:	42.58

Model 2 : Soil Morphology





Questions

6. What is soil?

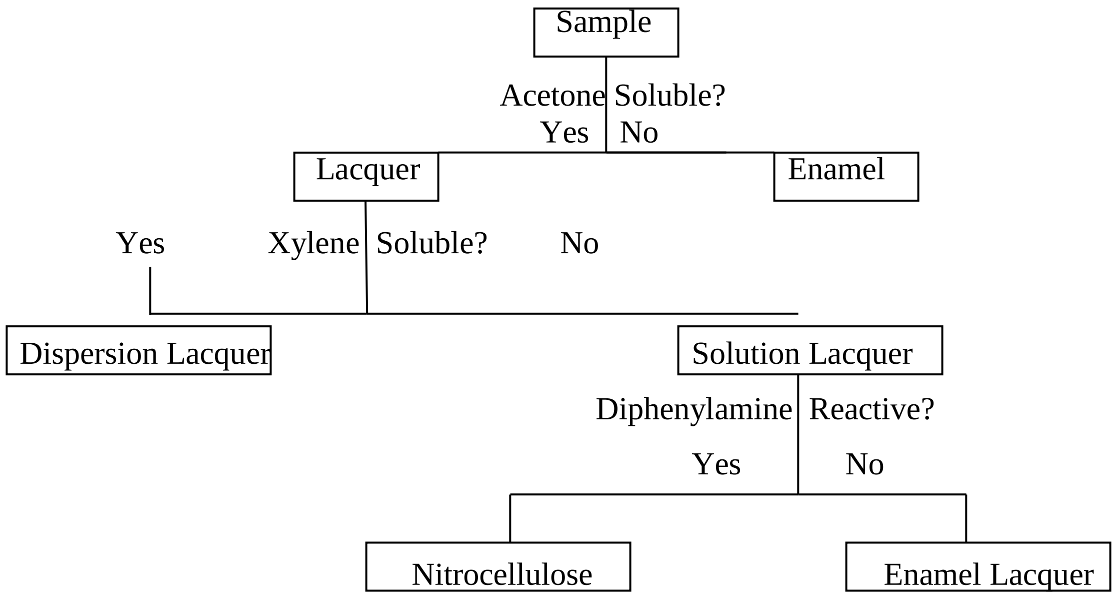
7. In lecture, ten distinct properties were identified that can be used to characterize soil. Identify as many as you can:

Exercises

8. Identify the types of cases you would expect soil evidence to be important in, and where you would find the evidence:

9. The picture to the right is a piece of evidence collected at a breaking and entering crime scene. List three class characteristics you would expect to find, and three individual characteristics that might be possible:

Model 3 : Paint Analysis



Questions

10. What analysis technique will help compare the colors of two separate paint samples?

Exercises

11. Give two examples of when paint analysis is used in forensic science

12. What are some of the components of paint and their purposes?

13. What principle of forensic science explains the transfer of paint from one car to another during an automobile accident?

Problems

14. Can you see a problem with using these tests for a hit and run accident?

References
Images- https://deathbetweenthecovers.files.wordpress.com/2013/04/glass1.jpg, viewed 7/2010
http://www.firearmsid.com/KSP%20Evidence%20Manual/illustrations/glass_1.gif, viewed 7/2010
http://www.thegreenyard.com.au/wp-content/uploads/2014/02/Soil-Profile.jpg, viewed 7/2010
http://southwest.library.arizona.edu/azso/fig004.jpg, viewed 7/2010

Spectroscopy and Chromatography:
Analysis of Chemical Evidence

What is involved in spectroscopy and chromatography… And what evidence is best suited to this type of analysis?

Why?

Chromatography separates mixtures, allowing for a quantitative analysis of what is in a mixture – allowing the comparison of an unknown to a known – or the purification of a sample before further analysis with a mass spectrophotometer.

Spectroscopy utilizes the absorption and/or emission of light to analyze evidence. Due to the duality of light, the fact that has properties of transverse waves AND particle-like properties, we can make very specific examinations of both energy and matter. Types of spectroscopy include the use of energy all along the electromagnetic spectrum of energy, with each type of energy helping to determine very specific things about the evidence being evaluated.

Learning Outcome

- Students will be able to identify the varied types of spectroscopy and the information provided by each type of spectroscopy.
- Students will be able to determine the type of spectroscopy best utilized during the examination of evidence.
- Students will be able to apply the concepts of spectrophotometry to an AES result
- Students will be able to identify the varied types of chromatography and the information provided by each type of chromatography
- Students will be able to determine the type of chromatography best utilized during the examination of evidence.
- Students will be able to apply the concepts of chromatography to TLC results

New Concepts

The absorption of different types of energy can cause varied results, from the excitation of electrons, the vibration of bonds in compounds, and the rotations of atoms around bonds inside a compound.

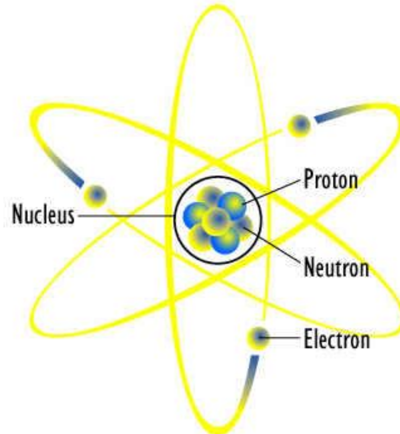
Examination of the absorption of energy, type of energy and amount of energy, can help identify both elements and compounds being examined.

The attractive forces of an unknown substance as it moves past a stationary phase can allow a mixture to be both identified and purified

Prerequisites

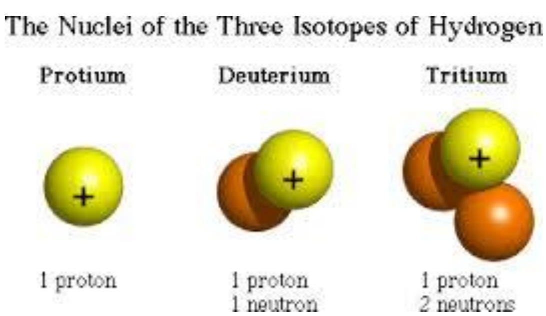
- Electromagnetic Spectrum of Energy, Elements, Compounds, Bohr's model of the atom
- Intermolecular forces of attraction

Model 1: Atomic Theory



Law of Conservation of Matter

Matter cannot be created or destroyed in chemical and common physical changes.



The Water Cycle
Background Information

Physical vs Chemical Change

Directions: Compare the characteristics of physical and chemical change, then answer the question below.

Physical Change	Chemical Change
--The physical properties (the way it looks, smells, feels, etc.) may or may not change	--The physical properties change.
--The change may be reversible.	--The change is not reversible
--A new substance *is not* produced.	--A new substance *is* produced.
Examples:	Examples:
--cutting logs to make firewood	--burning firewood to make carbon and heat
--falling leaves from a tree	--composting leaves into soil
--mining bauxite from the ground	--making aluminum from bauxite.

Is water cycling a physical or chemical change?

Questions:

1. The smallest particle of an element that can exist and still retain its identity as that element is a(n)

2. Isotopes are:

3. Rewrite the Law of the Conservation of mass in your own words:

4. Which is not a physical property of matter?
   (a) mass
   (b) combustion energy
   (c) refractive index
   (d) color
   (e) temperature

5. What vocabulary might you use to describe a chemical phase?

Problems:

6. What are the two main areas of analysis in analytical chemistry to be covered in lecture?

7. Just looking at words, what is the difference between *qualitative* analysis and *quantitative* analysis?

Model 2 : Types of Chromatography – use this table during lecture to organize information

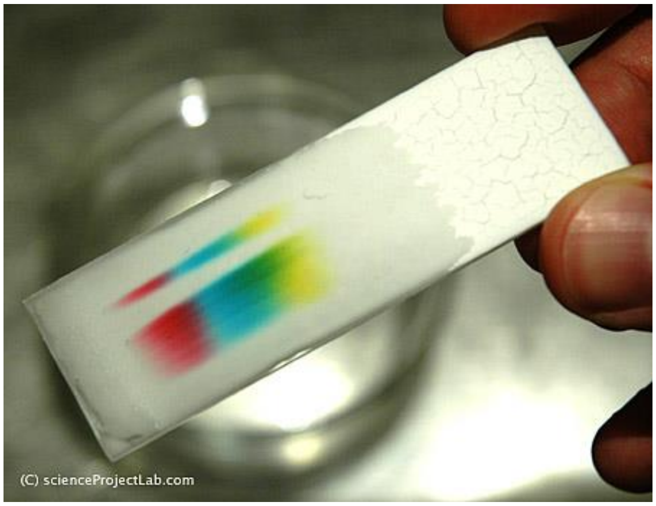
Technique	Stationary Phase/Mobile Phase	How do we use this in identification	Facts worth knowing AND Evidence being explore
Column	SP – MP –		
Gas (GC)	SP – MP –		
Paper	SP – MP –		
Thin Layer (TLC)	SP – MP –		
Liquid (HPLC)	SP – MP –		

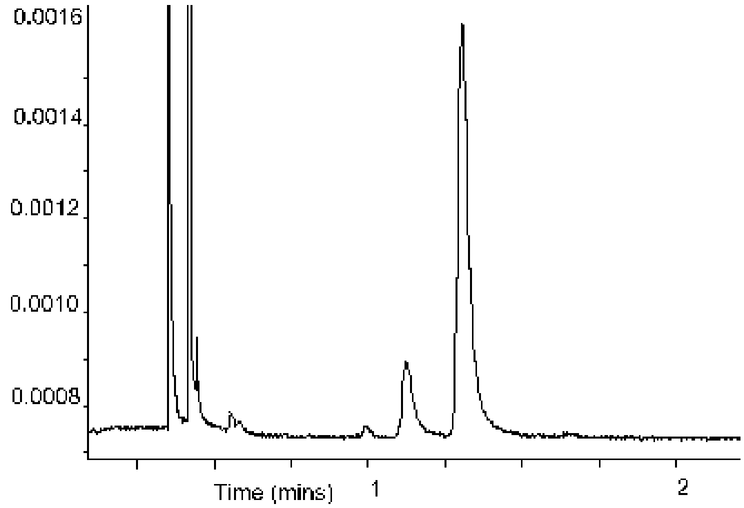
Two other types: Size Exclusion and Ion Exchange…

Questions

1. A technique for separating the components of a mixture is
2. The mobile phase in gas chromatography is
3. The stationary phase in paper chromatography employing water as the solvent is
4. A compound can tentatively be identified by gas chromatography from its
5. In terms of shape and volume, differentiate between solids, liquids and gases.
6. What is the difference between a homogeneous and a heterogeneous mixture?
7. What are the methods used to physically separate a mixture?
8. What is fractional distillation?

Model 2 : Reading Chromatographic Results





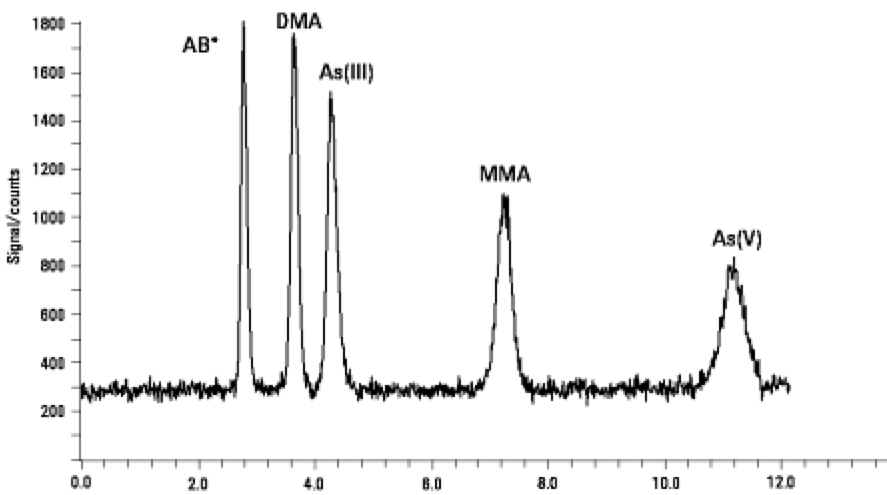


Figure: 5-µL injection of 5 µg/L standard.

Questions

9. What is retention factor, Rf?

10. What information is learned about a sample by computing the relative areas under the peaks of a gas chromatogram like the one shown?

11. A sample of purple ink is to be separated using paper chromatography. The ink is dissolved in methanol and a strip of chromatography paper is dipped into the solution. Identify the stationary stage and the mobile phase. After twenty minutes a blue mark is found 1 cm from the solution and a red mark 1.5 cm from the solution on the paper. Which color has the stronger attraction for the paper?

12. How do you know how many components are in a mixture when using gas chromatography?

Model 3 : Types of Spectroscopy

Technique	Electromagnetic Energy Used	How do we use this in identification	Facts worth knowing AND Evidence being explore
Mass Spec			
Atomic Absorption			
Atomic Emission			
Neutron Activation			
Vibrational			
Nuclear Magnetic Resonance			

Questions

1. What is the relationship between the frequency of light and its energy?

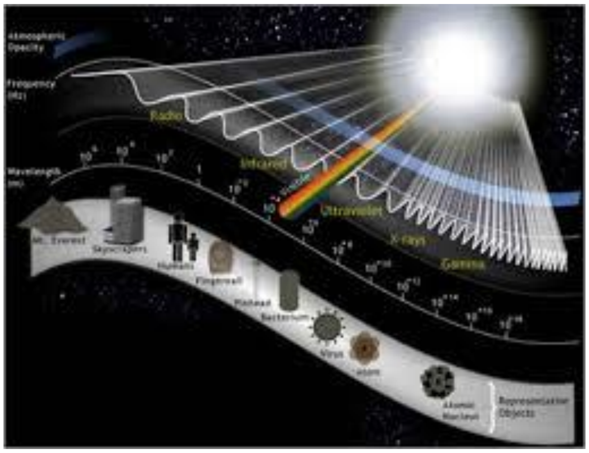
2. What must an electron do to move from a lower energy level to a higher energy level?

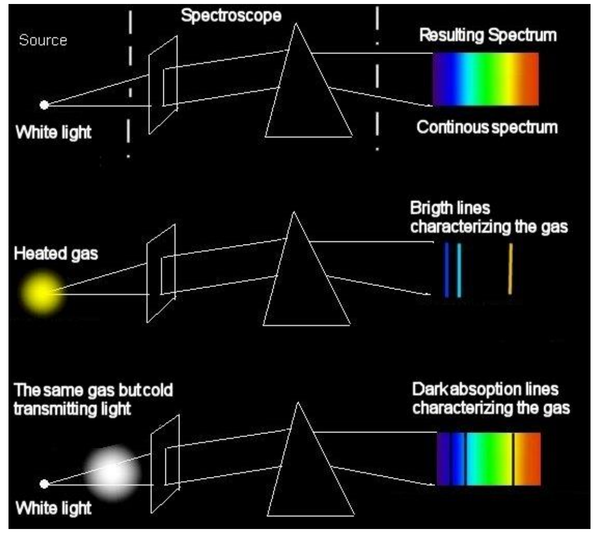
3. What is meant by the terms ground state and excited state for an electron?

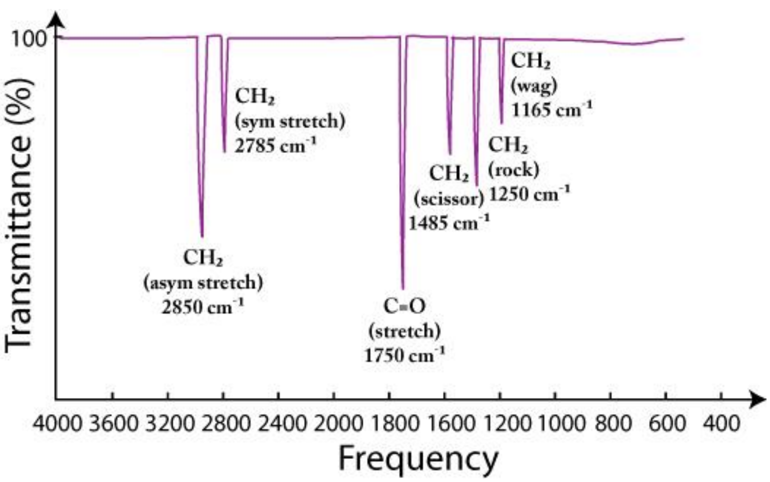
4. What is the difference between an emission and an absorption spectrum?

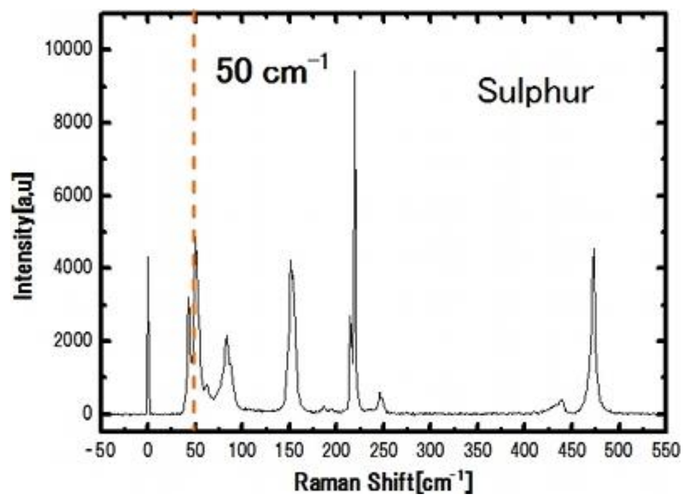
5. What are some of the advantages found in using neutron activation analysis? What is the major disadvantage to this technique?

Model 4 : Reading Spectroscopic Results









Questions

6. What are organic functional groups? How do they play a big role in UV-Visible spectroscopy?

7. How does the use of infrared light in spectroscopy differ from the use of visible or UV light?

8. IR spectra are often very complex. How does this complexity work in favor of the forensic chemist?

9. Which analysis method is used in breath-alcohol concentration determination?

10. How does a mass spectrometer work?

References:

Images –
http://www.pennmedicine.org/health_info/images/19432.jpg
http://www.biosbcc.net/b100cardio/img/FG20_01.jpg
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Appendix B

SYRACUSE UNIVERSITY
Institutional Review Board
MEMORANDUM

TO:	James Spencer
DATE:	May 2, 2014
SUBJECT:	**Determination of Exemption from Regulations**
IRB #:	14-103
TITLE:	*Assessing the Quantified Impact of POGIL on an Introductory Forensic Science Survey Course*

The above referenced application, submitted for consideration as exempt from federal regulations as defined in 45 C.F.R. 46, has been evaluated by the Institutional Review Board (IRB) for the following:

1. determination that it falls within the one or more of the five exempt categories allowed by the organization;
2. determination that the research meets the organization's ethical standards.

It has been determined by the IRB this protocol qualifies for exemption and has been assigned to category **4**. This authorization will remain active for a period of five years from **May 1, 2014** until **April 30, 2019**.

CHANGES TO PROTOCOL: Proposed changes to this protocol during the period for which IRB authorization has already been given, cannot be initiated without additional IRB review. If there is a change in your research, you should notify the IRB immediately to determine whether your research protocol continues to qualify for exemption or if submission of an expedited or full board IRB protocol is required. Information about the University's human participants protection program can be found at: http://orip.syr.edu/human-research/human-research-irb.html Protocol changes are requested on an amendment application available on the IRB web site; please reference your IRB number and attach any documents that are being amended.

STUDY COMPLETION: Study completion is when all research activities are complete or when a study is closed to enrollment and only data analysis remains on data that have been de-identified. A Study Closure Form should be completed and submitted to the IRB for review (Study Closure Form).

Thank you for your cooperation in our shared efforts to assure that the rights and welfare of people participating in research are protected.

Tracy J. Cromp

Tracy Cromp, M.S.W.
Director

Note to Faculty Advisor: This notice is only mailed to faculty. If a student is conducting this study, please forward this information to the student researcher.
DEPT: Department of Chemistry, CST – 329 Hall of Languages CC: Tyna Meeks

Office of Research Integrity and Protections
121 Bowne Hall Syracuse, New York 13244-1200
(Phone) 315.443.3013 ♦ (Fax) 315.443.9889
orip@syr.edu ♦ www.orip.syr.edu

Appendix C

Term	Ethnicity	Gender	SAT	Acad. Plan	Exam 1	Exam 2	Exam 3	Final	Summative
0	0	0	1090	0	50	53.3	77.1	68.9	62.33
0	0	0	1230	0	76.7	60	57.1	66.7	65.13
0	0	1	1300	1	60	60	68.6	57.8	61.6
0	2	0	1220	0	60	43.3	54.3	68.9	56.63
0	2	0	1180	0	73.3	63.3	80	62.2	69.7
0	0	1	1480	0	76.7	80	77.1	77.8	77.9
0	0	1	1330	0	63.3	66.7	65.7	60	63.93
0	0	0	1340	1	76.7	83.3	74.3	66.7	75.25
0	0	0	1350	0	80	50	80	68.9	69.73
0	0	1	1340	0	73.3	76.7	74.3	66.7	72.75
0	0	0	1240	0	66.7	63.3	71.4	37.8	59.8
0	0	1	1190	0	56.7	53.3	68.6	57.8	59.1
0	0	1	1270	0	66.7	76.7	65.7	73.3	70.6
0	5	1	1380	0	80	56.7	74.3	68.9	69.98
0	0	1	1280	0	70	73.3	82.9	68.9	73.78
0	0	1	1370	0	80	90	74.3	62.2	76.63
0	0	1	1420	0	83.3	73.3	85.7	68.9	77.8
0	5	1	1320	0	53.3	66.7	65.7	64.4	62.53
0	1	1	1280	1	60	63.3	74.3	55.6	63.3
0	3	1	1440	0	76.7	83.3	82.9	82.2	81.28
0	0	0	1320	0	76.7	70	88.6	71.1	76.6
0	0	1	1400	0	93.3	90	85.7	77.8	86.7
0	0	1	1210	0	53.3	53.3	62.9	75.6	61.28
0	0	1	1270	0	70	66.7	65.7	75.6	69.5
0	0	1	1220	1	70	73.3	85.7	73.3	75.58
0	0	1	1230	1	80	80	88.6	77.8	81.6
0	0	0	1020	0	46.7	63.3	62.9	60	58.23
0	0	0	1140	0	60	60	71.4	66.7	64.53
0	0	1	1110	0	70	56.7	71.4	73.3	67.85
0	0	1	1430	0	76.7	73.3	74.3	68.9	73.3
0	0	0	1350	0	63.3	60	77.1	64.4	66.2
0	0	1	1130	0	60	56.7	62.9	71.1	62.68
0	0	1	1180	0	76.7	80	82.9	73.3	78.23
0	2	1	1030	1	53.3	60	77.1	75.6	66.5
0	0	1	1130	1	56.7	76.7	74.3	77.8	71.38
0	0	1	1070	0	46.7	73.3	57.1	60	59.28
0	0	0	1340	1	80	83.3	85.7	75.6	81.15
0	0	0	1210	0	50	56.7	54.3	57.8	54.7
0	0	1	1250	0	63.3	73.3	71.4	57.8	66.45
0	5	0	1170	0	70	73.3	65.7	64.4	68.35

0	0	0	1370	0	70	83.3	80	68.9	75.55
0	0	0	1340	0	46.7	63.3	65.7	68.9	61.15
0	0	0	1180	0	53.3	63.3	65.7	66.7	62.25
0	0	1	1080	0	56.7	53.3	37.1	64.4	52.88
0	0	1	1080	0	53.3	43.3	37.1	55.6	47.33
0	0	1	1040	0	33.3	36.7	42.9	46.7	39.9
0	0	1	1330	0	70	80	68.6	73.3	72.98
0	0	1	1080	0	56.7	46.7	74.3	53.3	57.75
0	1	1	1190	0	70	73.3	45.7	68.9	64.48
0	1	1	970	0	50	50	62.9	48.9	52.95
0	0	1	1030	1	40	30	48.6	48.9	41.88
0	0	1	1030	0	70	43.3	74.3	68.9	64.13
0	0	1	1050	0	70	70	65.7	64.4	67.53
0	0	1	1320	0	66.7	66.7	62.9	75.6	67.98
0	0	0	940	0	43.3	36.7	51.4	62.2	48.4
0	0	1	1290	0	56.7	60	62.9	64.4	61
0	1	1	980	0	56.7	43.3	60	57.8	54.45
0	0	0	1260	0	70	76.7	85.7	77.8	77.55
0	0	1	1280	0	40	66.7	57.1	55.6	54.85
0	5	0	1250	0	63.3	50	65.7	75.6	63.65
0	0	0	1290	0	60	70	74.3	57.8	65.53
0	0	0	1120	0	50	60	54.3	55.6	54.98
0	5	1	1230	0	53.3	66.7	60	55.6	58.9
0	5	1	1130	1	63.3	53.3	74.3	71.1	65.5
0	0	1	1010	0	46.7	50	48.6	55.6	50.23
0	0	1	1120	0	63.3	60	71.4	64.4	64.78
0	1	1	1100	0	46.7	73.3	54.3	53.3	56.9
0	0	1	1160	0	33.3	60	82.9	77.8	63.5
0	0	1	1240	0	63.3	53.3	68.6	62.2	61.85
0	0	1	1210	0	70	83.3	82.9	66.7	75.73
0	0	1	1270	0	56.7	56.7	42.9	60	54.08
0	5	1	1120	0	43.3	36.7	37.1	57.8	43.73
0	1	0	1150	0	70	70	65.7	68.9	68.65
0	3	1	1080	0	63.3	63.3	57.1	64.4	62.03
0	0	1	1260	0	63.3	50	71.4	68.9	63.4
0	0	1	1340	0	80	80	88.6	75.6	81.05
0	1	0	950	1	56.7	30	45.7	55.6	47
0	1	1	1010	0	63.3	56.7	42.9	48.9	52.95
0	1	0	880	0	70	43.3	62.9	44.4	55.15
0	4	1	1140	0	73.3	73.3	62.9	48.9	64.6
0	0	1	1330	0	73.3	73.3	74.3	77.8	74.68
0	3	0	1160	1	66.7	73.3	80	71.1	72.78
0	0	1	1340	0	56.7	73.3	60	44.4	58.6

0	0	1	1200	0	70	76.7	88.6	60	73.83
0	5	1	1170	0	53.3	60	54.3	66.7	58.58
0	0	0	1360	0	53.3	66.7	88.6	73.3	70.48
0	1	1	1140	0	73.3	46.7	57.1	55.6	58.18
0	0	1	870	0	50	50	60	44.4	51.1
0	0	0	1230	0	66.7	66.7	77.1	68.9	69.85
0	0	1	1200	0	76.7	63.3	77.1	73.3	72.6
0	5	0	1070	1	50	53.3	54.3	48.9	51.63
0	0	1	1060	0	73.3	76.7	77.1	75.6	75.68
0	0	1	1140	1	80	70	68.6	68.9	71.88
0	3	0	950	1	63.3	63.3	74.3	53.3	63.55
0	1	1	1030	0	60	53.3	62.9	55.6	57.95
0	0	0	1360	0	60	63.3	57.1	68.9	62.33
0	0	1	1290	0	86.7	70	77.1	82.2	79
0	0	1	1080	0	53.3	70	60	66.7	62.5
0	0	1	1110	0	46.7	46.7	42.9	51.1	46.85
0	0	0	1350	0	73.3	63.3	77.1	68.9	70.65
0	0	0	1360	0	63.3	56.7	60	60	60
0	0	1	1200	0	63.3	73.3	71.4	80	72
0	0	0	1220	0	66.7	50	57.1	53.3	56.78
0	0	1	1040	0	66.7	43.3	57.1	53.3	55.1
0	0	1	1380	0	76.7	70	60	68.9	68.9
0	0	0	1150	0	66.7	60	65.7	75.6	67
0	0	0	1300	0	83.3	80	62.9	57.8	71
0	0	0	950	1	73.3	60	68.6	68.9	67.7
0	2	1	1070	0	60	43.3	54.3	51.1	52.18
0	0	0	1230	0	66.7	53.3	60	71.1	62.78
0	0	1	1280	0	60	63.3	62.9	57.8	61
0	2	1	960	0	36.7	40	51.4	51.1	44.8
0	0	0	1120	0	66.7	53.3	65.7	68.9	63.65
0	0	0	1400	0	60	66.7	60	71.1	64.45
0	0	1	1140	0	63.3	83.3	82.9	77.8	76.83
0	0	0	1230	0	63.3	43.3	57.1	64.4	57.03
0	0	1	1260	0	56.7	60	57.1	68.9	60.68
0	5	1	1270	0	50	60	80	64.4	63.6
0	0	0	1180	0	60	53.3	68.6	71.1	63.25
0	0	1	1390	0	50	66.7	65.7	66.7	62.28
0	5	0	1060	1	60	63.3	54.3	57.8	58.85
0	0	1	990	0	50	76.7	62.9	62.2	62.95
0	5	1	1290	0	63.3	66.7	71.4	68.9	67.58
0	0	0	1040	1	46.7	33.3	45.7	46.7	43.1
0	0	1	1130	0	53.3	63.3	60	51.1	56.93
0	0	0	1180	0	56.7	33.3	62.9	53.3	51.55

0	2	1	970	0	40	46.7	62.9	57.8	51.85
0	5	0	1080	0	70	63.3	60	66.7	65
0	0	0	1190	1	46.7	53.3	57.1	68.9	56.5
0	0	0	1110	0	46.7	46.7	60	71.1	56.13
0	0	0	1140	0	76.7	70	85.7	73.3	76.43
0	0	0	1130	1	86.7	76.7	77.1	77.8	79.58
0	0	0	1140	0	56.7	66.7	62.9	51.1	59.35
0	5	1	1360	0	50	73.3	54.3	53.3	57.73
0	5	1	1220	0	50	60	77.1	68.9	64
0	5	1	1270	0	63.3	60	60	68.9	63.05
0	2	1	900	0	46.7	43.3	48.6	53.3	47.98
0	0	1	1190	0	56.7	56.7	62.9	66.7	60.75
0	0	0	1170	0	53.3	60	54.3	55.6	55.8
0	0	1	1270	0	60	63.3	80	68.9	68.05
0	2	0	1050	1	50	43.3	48.6	57.8	49.93
0	5	1	970	1	56.7	56.7	57.1	57.8	57.08
0	0	0	1250	0	43.3	80	88.6	75.6	71.88
0	1	1	1200	0	70	73.3	80	71.1	73.6
0	0	0	1180	0	70	53.3	71.4	71.1	66.45
0	1	1	1030	0	50	80	65.7	62.2	64.48
0	0	1	1160	0	66.7	60	60	62.2	62.23
0	1	1	940	0	56.7	66.7	65.7	44.4	58.38
0	0	1	1100	0	63.3	73.3	74.3	51.1	65.5
0	0	1	1200	0	46.7	50	68.6	73.3	59.65
0	0	0	1190	0	60	63.3	60	62.2	61.38
0	0	1	1180	0	56.7	56.7	68.6	62.2	61.05
0	0	1	1060	0	56.7	53.3	48.6	57.8	54.1
0	5	0	1100	1	56.7	60	80	55.6	63.08
0	0	0	1150	0	43.3	70	80	68.9	65.55
0	0	1	1260	0	76.7	76.7	45.7	62.2	65.33
0	0	0	1080	1	30	76.7	77.1	55.6	59.85
0	0	1	1130	0	80	73.3	71.4	80	76.18
0	0	1	1250	0	60	73.3	65.7	66.7	66.43
0	0	1	1230	0	60	60	77.1	48.9	61.5
0	0	0	1190	0	73.3	60	68.6	51.1	63.25
0	0	1	1250	0	63.3	60	60	53.3	59.15
0	0	0	1180	0	80	83.3	94.3	71.1	82.18
0	1	1	1020	0	56.7	46.7	60	46.7	52.53
0	1	1	1260	0	56.7	63.3	60	68.9	62.23
0	0	0	1350	0	76.7	80	88.6	77.8	80.78
0	0	1	1250	1	46.7	50	57.1	48.9	50.68
0	0	1	990	0	36.7	20	48.6	37.8	35.78
0	0	1	1310	1	76.7	60	82.9	80	74.9

0	5	1	1280	0	60	63.3	71.4	66.7	65.35
0	2	0	1120	0	73.3	70	71.4	75.6	72.58
0	0	1	1310	0	70	70	77.1	66.7	70.95
0	0	0	1390	0	73.3	70	77.1	75.6	74
0	0	0	1040	0	50	53.3	42.9	42.2	47.1
0	0	0	1250	0	50	73.3	62.9	57.8	61
0	2	1	1030	0	46.7	36.7	54.3	48.9	46.65
0	0	0	1220	1	70	53.3	54.3	64.4	60.5
0	0	1	1300	0	56.7	56.7	65.7	71.1	62.55
0	0	1	1150	0	66.7	73.3	80	77.8	74.45
0	0	0	1190	0	56.7	50	77.1	62.2	61.5
0	0	1	1280	0	73.3	73.3	68.6	68.9	71.03
0	0	0	1150	1	63.3	46.7	65.7	60	58.93
0	0	0	1390	0	73.3	70	85.7	73.3	75.58
0	0	1	1310	0	82.4	79.4	83.7	83.3	82.2
0	0	0	1380	0	85.3	82.4	83.7	75	81.6
0	0	1	1450	0	82.4	76.5	95.3	77.1	82.83
0	0	0	1370	0	76.5	73.5	55.8	70.8	69.15
0	0	0	1370	0	82.4	70.6	72.1	77.1	75.55
0	1	0	1340	1	91.2	73.5	90.7	77.1	83.13
0	0	0	1240	0	85.3	73.5	53.5	64.6	69.23
0	1	1	1200	0	67.6	82.4	72.1	66.7	72.2
0	1	0	1170	0	73.5	58.8	58.1	70.8	65.3
0	2	1	1140	0	61.8	55.9	53.5	64.6	58.95
0	2	1	1150	0	70.6	70.6	58.1	79.2	69.63
0	0	1	1180	1	64.7	73.5	58.1	47.9	61.05
0	0	1	1280	0	70.6	58.8	48.8	60.4	59.65
0	0	0	1330	0	85.3	70.6	79.1	70.8	76.45
0	0	1	1140	0	70.6	70.6	55.8	64.6	65.4
0	0	1	1410	0	91.2	79.4	76.7	81.3	82.15
0	5	1	1330	0	97.1	85.3	86	85.4	88.45
0	0	1	1160	0	67.6	73.5	74.4	75	72.63
0	0	1	1060	0	64.7	67.6	72.1	64.6	67.25
0	0	1	1210	0	64.7	52.9	55.8	62.5	58.98
0	1	1	1070	0	88.2	70.6	62.8	62.5	71.03
0	5	1	1270	0	79.4	79.4	79.1	66.7	76.15
0	0	0	1060	1	88.2	73.5	62.8	60.4	71.23
0	0	0	1260	0	85.3	76.5	58.1	81.3	75.3
0	0	1	1050	0	55.9	70.6	39.5	54.2	55.05
0	0	1	1320	0	97.1	82.4	81.4	85.4	86.58
0	0	1	1200	0	64.7	82.4	58.1	75	70.05
0	3	1	1310	0	82.4	76.5	76.7	79.2	78.7
0	2	1	1220	0	88.2	82.4	74.4	81.3	81.58

0	0	0	1270	0	82.4	76.5	76.7	81.3	79.23
0	1	1	1000	0	67.6	61.8	51.2	64.6	61.3
0	1	1	1050	0	73.5	55.9	62.8	62.5	63.68
0	0	1	1120	1	58.8	85.3	72.1	70.8	71.75
0	0	0	1200	0	67.6	76.5	55.8	66.7	66.65
0	0	1	1360	0	79.4	73.5	60.5	77.1	72.63
0	2	0	980	0	52.9	64.7	48.8	52.1	54.63
0	0	1	1130	0	70.6	55.9	65.1	56.3	61.98
0	0	0	1230	0	73.5	67.6	76.7	64.6	70.6
0	0	1	1010	1	58.8	61.8	53.5	54.2	57.08
0	0	0	1300	0	55.9	58.8	39.5	72.9	56.78
0	0	0	1260	0	82.4	79.4	67.4	70.8	75
0	0	1	1190	0	64.7	73.5	74.4	77.1	72.43
0	0	1	1110	0	61.8	64.7	67.4	70.8	66.18
0	3	1	1130	0	67.6	70.6	67.4	72.9	69.63
0	1	1	1130	0	73.5	79.4	69.8	68.8	72.88
0	0	0	1150	0	58.8	64.7	34.9	52.1	52.63
0	1	1	1180	1	76.5	76.5	74.4	62.5	72.48
0	0	1	1240	0	70.6	64.7	62.8	58.3	64.1
0	3	1	1260	0	58.8	67.6	51.2	75	63.15
0	0	1	1280	0	70.6	67.6	69.8	83.3	72.83
0	0	1	1170	0	88.2	79.4	79.1	70.8	79.38
0	0	1	990	0	58.8	67.6	62.8	47.9	59.28
0	1	0	990	1	47.1	35.3	37.2	54.2	43.45
0	5	1	1160	0	82.4	79.4	81.4	64.6	76.95
0	0	0	1150	0	91.2	70.6	67.4	79.2	77.1
0	0	1	1180	0	82.4	82.4	90.7	75	82.63
0	0	1	1300	0	82.4	76.5	69.8	70.8	74.88
0	5	1	1190	0	70.6	64.7	72.1	66.7	68.53
0	0	1	1140	0	76.5	58.8	58.1	54.2	61.9
0	0	1	1160	0	67.6	61.8	48.8	58.3	59.13
0	3	1	1290	0	64.7	61.8	79.1	79.2	71.2
0	2	0	930	0	61.8	58.8	46.5	54.2	55.33
0	5	1	1090	0	52.9	76.5	53.5	62.5	61.35
0	0	1	1170	0	82.4	85.3	69.8	77.1	78.65
0	3	1	1280	0	50	61.8	46.5	50	52.08
0	5	1	1150	0	97.1	73.5	72.1	70.8	78.38
0	5	1	1260	0	73.5	91.2	81.4	72.9	79.75
0	5	1	1350	0	70.6	67.6	62.8	68.8	67.45
0	3	1	1270	0	82.4	70.6	67.4	52.1	68.13
0	0	0	1160	0	61.8	67.6	41.9	62.5	58.45
0	0	1	1120	0	55.9	73.5	51.2	70.8	62.85
0	0	0	1140	0	82.4	76.5	79.1	75	78.25

0	0	0	1180	0	76.5	70.6	81.4	66.7	73.8
0	0	1	950	0	44.1	64.7	48.8	58.3	53.98
0	0	0	1260	0	79.4	85.3	79.1	79.2	80.75
0	0	1	1270	0	76.5	61.8	74.4	70.8	70.88
0	0	0	1230	0	79.4	73.5	65.1	72.9	72.73
0	0	1	1110	1	79.4	82.4	81.4	72.9	79.03
0	0	1	1240	0	94.1	82.4	62.8	79.2	79.63
0	0	1	1100	0	61.8	67.6	53.5	72.9	63.95
0	0	1	900	0	79.4	85.3	60.5	70.8	74
0	0	1	1340	0	50	67.6	51.2	56.3	56.28
0	0	1	1160	0	88.2	85.3	79.1	64.6	79.3
0	0	0	1030	0	97.1	88.2	72.1	83.3	85.18
0	0	1	1090	0	76.5	73.5	65.1	64.6	69.93
0	1	1	960	1	88.2	82.4	81.4	75	81.75
0	0	0	1270	0	52.9	52.9	46.5	41.7	48.5
0	0	1	1060	0	85.3	70.6	74.4	70.8	75.28
0	0	1	1210	0	64.7	70.6	48.8	50	58.53
0	5	0	1380	0	58.8	70.6	55.8	50	58.8
0	5	0	1270	0	73.5	82.4	72.1	77.1	76.28
0	0	1	1250	0	88.2	82.4	81.4	87.5	84.88
0	3	1	1020	1	88.2	82.4	81.4	72.9	81.23
0	0	1	1370	0	85.3	67.6	79.1	68.8	75.2
0	0	1	1110	0	85.3	82.4	65.1	77.1	77.48
0	0	0	1140	0	88.2	85.3	65.1	72.9	77.88
0	0	1	1260	0	64.7	61.8	67.4	62.5	64.1
0	1	1	1070	0	58.8	41.2	32.6	45.8	44.6
0	0	1	1400	0	91.2	82.4	86	75	83.65
0	1	1	950	0	64.7	41.2	39.5	50	48.85
0	3	0	1320	1	88.2	94.1	90.7	95.8	92.2
0	0	0	1380	0	76.5	85.3	76.7	77.1	78.9
0	0	1	1220	0	91.2	67.6	88.4	83.3	82.63
0	5	0	1270	0	61.8	64.7	60.5	66.7	63.43
0	1	0	880	1	35.3	61.8	34.9	45.8	44.45
0	5	1	1450	1	88.2	82.4	65.1	70.8	76.63
0	5	1	1390	0	88.2	76.5	72.1	75	77.95
0	0	0	1140	0	79.4	67.6	51.2	72.9	67.78
0	0	1	1200	0	61.8	58.8	67.4	56.3	61.08
0	0	1	1140	0	47.1	55.9	81.4	60.4	61.2
0	0	0	1160	1	82.4	88.2	74.4	60.4	76.35
0	5	1	1190	0	58.8	61.8	67.4	58.3	61.58
0	0	1	1140	0	76.5	70.6	62.8	54.2	66.03
0	0	1	1110	1	67.6	82.4	67.4	62.5	69.98
0	0	1	1230	0	91.2	82.4	76.7	72.9	80.8

0	0	0	1170	1	61.8	73.5	55.8	58.3	62.35
0	1	1	1120	0	61.8	58.8	44.2	66.7	57.88
0	2	1	1010	0	82.4	76.5	65.1	60.4	71.1
0	0	0	1160	0	61.8	61.8	41.9	41.7	51.8
0	1	1	1090	0	67.6	70.6	74.4	68.8	70.35
0	0	1	1380	0	94.1	85.3	86	91.7	89.28
0	0	0	1400	0	76.5	61.8	55.8	70.8	66.23
0	0	0	1290	0	70.6	82.4	79.1	70.8	75.73
0	3	1	1260	0	64.7	73.5	60.5	70.8	67.38
0	0	0	1210	0	79.4	64.7	65.1	75	71.05
0	0	0	1360	0	82.4	79.4	86	77.1	81.23
0	0	0	1180	0	67.6	67.6	39.5	60.4	58.78
0	0	1	1190	0	79.4	73.5	72.1	72.9	74.48
0	5	1	1130	0	61.8	67.6	69.8	68.8	67
0	1	1	1220	0	64.7	73.5	41.9	66.7	61.7
0	5	1	1230	0	52.9	76.5	62.8	54.2	61.6
0	1	1	950	0	52.9	64.7	46.5	56.3	55.1
0	0	1	1410	0	82.4	76.5	62.8	64.6	71.58
0	0	1	1280	0	64.7	61.8	55.8	52.1	58.6
0	0	1	1300	1	88.2	70.6	67.4	87.5	78.43
0	5	0	1240	0	64.7	79.4	76.7	66.7	71.88
0	0	1	1330	1	82.4	82.4	62.8	66.7	73.58
0	0	1	1070	0	55.9	73.5	48.8	35.4	53.4
0	0	1	1160	0	67.6	58.8	53.5	47.9	56.95
0	1	1	1050	1	55.9	58.8	46.5	50	52.8
0	5	1	1010	0	44.1	76.5	46.5	62.5	57.4
0	0	0	1420	0	82.4	82.4	88.4	72.9	81.53
0	0	0	1260	0	91.2	79.4	81.4	70.8	80.7
0	5	1	1440	0	76.5	85.3	86	83.3	82.78
0	0	1	1130	0	76.5	73.5	74.4	83.3	76.93
0	2	0	1290	0	97.1	79.4	83.7	72.9	83.28
0	0	1	1300	0	85.3	79.4	55.8	64.6	71.28
0	5	1	1430	0	67.6	67.6	51.2	64.6	62.75
0	0	1	1300	0	52.9	73.5	58.1	62.5	61.75
0	0	0	1350	0	88.2	73.5	81.4	79.2	80.58
0	5	0	1010	1	85.3	73.5	53.5	47.9	65.05
0	0	0	1240	1	82.4	73.5	67.4	62.5	71.45
0	5	1	860	0	58.8	58.8	48.8	58.3	56.18
0	0	1	1110	0	41.2	76.5	48.8	66.7	58.3
0	0	1	1310	0	76.5	67.6	69.8	77.1	72.75
0	0	1	1100	0	76.5	73.5	72.1	77.1	74.8
0	5	0	1070	0	76.5	76.5	34.9	50	59.48
0	0	1	1210	0	85.3	79.4	69.8	72.9	76.85

0	2	1	1020	1	70.6	52.9	67.4	68.8	64.93
0	2	0	1180	0	91.2	55.9	58.1	64.6	67.45
0	0	1	1140	0	88.2	76.5	62.8	66.7	73.55
0	5	1	1240	0	79.4	82.4	72.1	66.7	75.15
0	0	1	1270	0	70.6	76.5	79.1	70.8	74.25
0	5	0	1320	0	82.4	70.6	86	75	78.5
0	0	1	1220	0	50	79.4	67.4	52.1	62.23
0	0	0	1160	0	73.5	67.6	62.8	62.5	66.6
0	0	1	1260	0	64.7	76.5	51.2	58.3	62.68
0	1	0	1080	0	64.7	58.8	53.5	43.8	55.2
0	1	1	980	0	47.1	61.8	55.8	50	53.68
0	0	1	1200	1	79.4	76.5	76.7	70.8	75.85
0	0	1	1290	0	94.1	76.5	76.7	75	80.58
0	0	0	1230	0	73.5	64.7	55.8	56.3	62.58
0	0	0	1150	0	70.6	70.6	41.9	52.1	58.8
0	0	1	1080	0	55.9	58.8	53.5	56.3	56.13
0	5	0	1180	0	50	61.8	39.5	58.3	52.4
0	0	1	1210	0	73.5	73.5	69.8	75	72.95
0	2	1	1100	0	50	73.5	46.5	54.2	56.05
0	5	0	1310	0	82.4	79.4	69.8	66.7	74.58
0	0	1	950	0	61.8	70.6	67.4	66.7	66.63
0	0	0	1340	1	64.7	76.5	69.8	68.8	69.95
0	0	1	1120	0	55.9	67.6	69.8	60.4	63.43
0	1	1	1120	0	70.6	67.6	58.1	58.3	63.65
0	0	0	1310	0	67.6	67.6	69.8	60.4	66.35
0	0	0	1200	1	58.8	76.5	65.1	54.2	63.65
0	0	1	1150	0	76.5	76.5	51.2	68.8	68.25
0	5	1	1010	0	81.8	67.9	70.6	61.9	70.55
0	0	1	1140	0	93.9	71.4	88.2	90.5	86
0	5	0	1190	0	87.9	82.1	76.5	81	81.88
0	0	1	1220	1	66.7	75	61.8	73.8	69.33
0	1	0	1080	1	75.8	67.9	50	57.1	62.7
0	2	1	1190	0	78.8	64.3	58.8	81	70.73
0	0	0	1300	0	93.9	71.4	73.5	64.3	75.78
0	0	1	1330	0	84.8	75	67.6	85.7	78.28
0	3	1	1460	0	84.8	75	73.5	71.4	76.18
0	3	1	1280	0	97	67.9	73.5	85.7	81.03
0	0	1	1310	1	93.9	89.3	88.2	88.1	89.88
0	0	1	1340	1	87.9	85.7	79.4	92.9	86.48
0	1	1	1240	0	87.9	71.4	64.7	81	76.25
0	0	1	1190	0	78.8	50	64.7	64.3	64.45
0	0	0	1260	1	75.8	85.7	85.3	83.3	82.53
0	0	1	1470	0	90.9	78.6	85.3	69	80.95

0	5	1	1280	0	87.9	82.1	64.7	81	78.93
0	2	1	1090	0	66.7	85.7	67.6	64.3	71.08
0	3	1	1410	0	90.9	71.4	67.6	88.1	79.5
0	5	1	1340	0	84.8	78.6	70.6	81	78.75
0	5	1	1330	0	93.9	75	82.4	88.1	84.85
0	0	0	1250	0	69.7	71.4	55.9	61.9	64.73
0	5	1	1150	0	81.8	78.6	55.9	76.2	73.13
0	0	1	1130	1	87.9	85.7	79.4	95.2	87.05
0	0	0	1320	0	87.9	71.4	79.4	78.6	79.33
0	1	0	1150	0	51.5	53.6	55.9	71.4	58.1
0	1	1	1020	0	66.7	75	64.7	59.5	66.48
0	5	1	1290	0	87.9	75	79.4	85.7	82
0	0	0	1370	0	81.8	57.1	50	76.2	66.28
0	0	1	1280	0	84.8	64.3	41.2	66.7	64.25
0	5	1	1240	0	90.9	71.4	55.9	76.2	73.6
0	0	1	1220	0	75.8	75	73.5	78.6	75.73
0	0	0	1190	0	90.9	57.1	64.7	69	70.43
0	1	1	940	0	60.6	75	50	45.2	57.7
0	2	1	990	0	75.8	67.9	88.2	90.5	80.6
0	3	1	1230	0	75.8	71.4	79.4	83.3	77.48
0	0	0	1280	0	69.7	46.4	67.6	54.8	59.63
0	0	0	1260	0	69.7	57.1	47.1	52.4	56.58
0	5	1	1000	0	72.7	71.4	76.5	64.3	71.23
0	0	1	1090	1	78.8	67.9	76.5	76.2	74.85
0	0	0	1350	0	69.7	75	73.5	69	71.8
0	1	0	1230	0	78.8	64.3	76.5	76.2	73.95
0	0	0	1100	0	63.6	60.7	58.8	76.2	64.83
0	0	1	1430	0	81.8	60.7	70.6	88.1	75.3
0	0	1	1070	0	63.6	46.4	61.8	66.7	59.63
0	0	0	1070	0	72.7	82.1	64.7	73.8	73.33
0	1	0	1000	0	42.4	46.4	58.8	40.5	47.03
0	0	1	1340	0	78.8	60.7	58.8	71.4	67.43
0	0	1	1190	0	81.8	82.1	64.7	90.5	79.78
0	0	1	1210	1	66.7	89.3	82.4	71.4	77.45
0	0	1	1220	0	84.8	71.4	82.4	83.3	80.48
0	0	1	1160	0	93.9	78.6	73.5	78.6	81.15
0	0	0	1220	0	75.8	57.1	64.7	83.3	70.23
0	0	1	1400	0	87.9	78.6	58.8	78.6	75.98
0	0	0	1280	0	81.8	89.3	58.8	85.7	78.9
0	0	1	1130	1	84.8	75	64.7	81	76.38
0	0	0	1440	0	69.7	82.1	73.5	73.8	74.78
0	0	0	1080	0	93.9	89.3	67.6	83.3	83.53
0	3	1	1310	0	78.8	85.7	76.5	66.7	76.93

0	3	1	1150	0	87.9	75	70.6	90.5	81
0	0	1	1080	0	87.9	50	58.8	73.8	67.63
0	0	0	1120	1	42.4	60.7	47.1	57.1	51.83
0	3	0	1400	0	72.7	89.3	64.7	71.4	74.53
0	0	1	1130	0	87.9	89.3	82.4	90.5	87.53
0	5	1	1120	0	84.8	57.1	50	54.8	61.68
0	0	0	1280	0	97	85.7	82.4	85.7	87.7
0	4	1	990	1	72.7	39.3	52.9	61.9	56.7
0	0	1	1310	1	81.8	67.9	85.3	73.8	77.2
0	0	1	1190	0	90.9	64.3	64.7	71.4	72.83
0	2	1	950	0	36.4	46.4	26.5	40.5	37.45
0	5	0	1280	0	87.9	85.7	85.3	78.6	84.38
0	0	1	1180	0	87.9	71.4	73.5	81	78.45
0	1	1	1040	0	87.9	39.3	64.7	35.7	56.9
0	0	0	1120	1	72.7	60.7	70.6	64.3	67.08
0	0	1	1390	0	93.9	78.6	76.5	92.9	85.48
0	3	1	1050	0	84.8	78.6	67.6	83.3	78.58
0	0	1	1130	1	72.7	78.6	55.9	76.2	70.85
0	1	1	1100	0	93.9	85.7	67.6	83.3	82.63
0	0	1	1280	0	87.9	92.9	70.6	73.8	81.3
0	5	0	1260	0	84.8	78.6	67.6	69	75
0	1	1	860	0	48.5	46.4	58.8	50	50.93
0	2	1	1210	0	90.9	78.6	76.5	78.6	81.15
0	0	0	1280	0	75.8	71.4	73.5	66.7	71.85
0	0	0	1070	1	78.8	89.3	76.5	83.3	81.98
0	0	0	1190	0	84.8	78.6	70.6	69	75.75
0	0	0	1300	0	87.9	60.7	70.6	73.8	73.25
0	1	0	940	0	66.7	64.3	55.9	66.7	63.4
0	0	1	1240	0	75.8	67.9	55.9	73.8	68.35
0	0	1	1130	0	90.9	96.4	82.4	92.9	90.65
0	0	1	1010	0	81.8	46.4	73.5	69	67.68
0	0	1	1200	1	78.8	67.9	64.7	71.4	70.7
0	0	1	1190	0	84.8	60.7	61.8	64.3	67.9
0	0	0	1260	0	84.8	78.6	73.5	76.2	78.28
0	0	0	1280	0	66.7	57.1	64.7	61.9	62.6
0	0	1	1230	0	75.8	71.4	61.8	66.7	68.93
0	0	1	1120	0	66.7	64.3	61.8	66.7	64.88
0	0	1	1200	0	87.9	64.3	70.6	59.5	70.58
0	3	1	960	0	54.5	57.1	41.2	47.6	50.1
0	0	1	1310	0	81.8	75	73.5	81	77.83
0	5	1	1240	0	84.8	71.4	50	59.5	66.43
0	0	1	1250	1	72.7	78.6	61.8	76.2	72.33
0	0	1	1140	0	54.5	39.3	61.8	52.4	52

0	3	1	1390	0	78.8	78.6	64.7	76.2	74.58
0	0	1	1070	0	93.9	78.6	73.5	81	81.75
0	3	0	1310	1	87.9	67.9	79.4	71.4	76.65
0	0	1	1330	0	84.8	75	79.4	85.7	81.23
0	1	1	1090	0	75.8	64.3	61.8	59.5	65.35
0	5	0	1150	0	81.8	71.4	61.8	76.2	72.8
0	5	0	1370	0	72.7	67.9	50	78.6	67.3
0	0	1	1190	0	78.8	67.9	67.6	85.7	75
0	2	1	1070	1	72.7	60.7	44.1	66.7	61.05
0	0	0	1030	0	75.8	60.7	70.6	61.9	67.25
0	0	0	1050	0	93.9	67.9	73.5	59.5	73.7
0	0	0	1180	0	84.8	60.7	70.6	66.7	70.7
0	1	1	1000	0	87.9	67.9	58.8	78.6	73.3
0	5	1	1170	0	45.5	71.4	67.6	64.3	62.2
0	0	1	1030	0	90.9	75	82.4	88.1	84.1
0	2	1	830	0	63.6	35.7	32.4	23.8	38.88
0	0	0	1360	0	84.8	75	70.6	83.3	78.43
0	2	1	890	1	66.7	60.7	52.9	69	62.33
0	0	1	1290	0	97	89.3	91.2	85.7	90.8
0	3	0	1240	1	81.8	82.1	85.3	81	82.55
0	0	0	1260	0	81.8	82.1	67.6	73.8	76.33
0	0	1	1370	0	84.8	64.3	76.5	78.6	76.05
0	5	1	1210	0	78.8	67.9	61.8	59.5	67
0	0	0	980	0	66.7	35.7	50	38.1	47.63
0	0	1	1070	0	63.6	60.7	70.6	64.3	64.8
0	4	1	1130	0	72.7	82.1	55.9	76.2	71.73
0	0	0	1170	1	81.8	75	58.8	76.2	72.95
0	0	1	1240	0	72.7	60.7	64.7	64.3	65.6
0	3	1	1140	1	90.9	82.1	64.7	92.9	82.65
0	1	1	1150	1	81.8	82.1	73.5	81	79.6
0	0	0	1260	0	90.9	75	73.5	73.8	78.3
0	0	1	1250	0	87.9	75	73.5	78.6	78.75
0	5	0	1260	0	87.9	92.9	76.5	85.7	85.75
0	0	1	1110	0	84.8	64.3	58.8	78.6	71.63
0	5	1	1200	0	72.7	71.4	70.6	83.3	74.5
0	0	0	1270	0	78.8	85.7	58.8	78.6	75.48
0	0	1	910	0	78.8	78.6	70.6	85.7	78.43
0	0	0	1400	0	63.6	60.7	67.6	66.7	64.65
0	0	0	1160	0	75.8	78.6	73.5	73.8	75.43
0	0	1	1180	0	84.8	78.6	76.5	95.2	83.78
0	1	1	990	1	75.8	46.4	64.7	57.1	61
0	0	0	1010	0	54.5	50	58.8	57.1	55.1
0	4	0	880	0	66.7	64.3	38.2	50	54.8

0	0	1	1250	0	87.9	64.3	70.6	78.6	75.35
0	1	1	1140	0	75.8	64.3	58.8	69	66.98
0	5	0	1420	0	87.9	89.3	79.4	81	84.4
0	0	1	1090	0	51.5	46.4	52.9	45.2	49
0	5	1	1320	0	78.8	60.7	67.6	71.4	69.63
0	0	1	1050	0	87.9	78.6	64.7	83.3	78.63
0	1	1	1170	0	93.9	82.1	88.2	83.3	86.88
0	0	0	1240	1	72.7	53.6	76.5	69	67.95
0	5	0	1300	0	72.7	75	64.7	66.7	69.78
0	0	0	1300	0	66.7	60.7	55.9	81	66.08
0	5	1	970	0	90.9	67.9	73.5	66.7	74.75
0	2	1	1070	0	69.7	50	73.5	69	65.55
0	0	1	1110	0	93.9	64.3	70.6	64.3	73.28
0	0	1	1290	0	90.9	64.3	64.7	61.9	70.45
0	0	1	1210	0	90.9	75	76.5	81	80.85
0	0	0	1100	0	81.8	75	58.8	71.4	71.75
0	2	1	980	0	78.8	78.6	58.8	61.9	69.53
0	5	0	1380	0	69.7	75	61.8	76.2	70.68
0	0	1	1410	0	78.8	57.1	61.8	76.2	68.48
0	0	0	1260	0	81.8	85.7	67.6	64.3	74.85
0	0	0	1200	1	78.8	92.9	79.4	90.5	85.4
0	0	1	1210	0	84.8	60.7	73.5	76.2	73.8
0	0	1	950	0	57.6	42.9	38.2	61.9	50.15
0	0	1	1210	1	90.9	82.1	73.5	90.5	84.25
0	0	0	1050	0	78.8	67.9	79.4	66.7	73.2
0	0	1	1000	0	51.5	53.6	41.2	57.1	50.85
0	0	1	1220	0	93.9	71.4	67.6	73.8	76.68
0	3	1	1160	0	84.8	71.4	58.8	71.4	71.6
0	0	0	1200	0	87.9	67.9	82.4	73.8	78
0	0	1	1230	0	78.8	78.6	64.7	78.6	75.18
0	3	1	1110	0	84.8	82.1	73.5	71.4	77.95
0	5	1	1140	1	57.6	78.6	67.6	81	71.2
0	0	1	1130	0	60.6	67.9	55.9	66.7	62.78
0	2	0	970	0	81.8	64.3	64.7	50	65.2
0	0	1	1210	0	72.7	67.9	61.8	73.8	69.05
0	3	1	1190	1	84.8	50	76.5	64.3	68.9
0	0	0	1040	0	75.8	60.7	44.1	69	62.4
0	0	0	1120	0	75.8	46.4	73.5	66.7	65.6
0	0	1	1410	1	93.9	85.7	85.3	92.9	89.45
0	0	0	1180	0	81.8	64.3	64.7	52.4	65.8
0	0	1	1360	0	81.8	75	67.6	85.7	77.53
0	5	1	1380	0	90.9	82.1	79.4	97.6	87.5
0	5	1	1310	0	66.7	67.9	44.1	52.4	57.78

0	0	1	1130	1	81.8	71.4	67.6	64.3	71.28
0	0	1	1030	0	78.8	60.7	70.6	73.8	70.98
0	0	0	1240	1	87.9	60.7	61.8	73.8	71.05
0	0	1	1270	0	81.8	78.6	79.4	97.6	84.35
0	1	1	870	0	75.8	67.9	70.6	57.1	67.85
0	0	0	1270	0	90.9	53.6	73.5	81	74.75
0	0	1	1300	0	87.1	66.7	60	89.7	75.88
0	0	1	1190	0	90.3	70	86.7	76.9	80.98
0	3	1	1420	0	64.5	56.7	63.3	87.2	67.93
0	5	1	1360	0	71	73.3	76.7	89.7	77.68
0	0	1	1170	0	74.2	70	63.3	84.6	73.03
0	0	1	1210	0	90.3	53.3	83.3	82.1	77.25
0	2	1	1170	0	67.7	40	73.3	66.7	61.93
0	0	1	1410	0	100	76.7	60	87.2	80.98
0	0	1	1470	0	83.9	66.7	73.3	82.1	76.5
0	0	1	1150	0	83.9	56.7	80	74.4	73.75
0	5	0	1280	0	71	46.7	63.3	66.7	61.93
0	0	0	1230	1	71	46.7	70	59	61.68
0	5	1	1020	0	67.7	63.3	83.3	74.4	72.18
0	0	0	1240	0	67.7	60	66.7	53.8	62.05
0	3	1	1110	0	80.6	76.7	90	84.6	82.98
0	3	0	1120	1	90.3	80	80	84.6	83.73
0	5	1	960	0	58.1	56.7	93.3	74.4	70.63
0	0	0	1250	0	87.1	70	83.3	74.4	78.7
0	0	1	1250	0	74.2	63.3	86.7	84.6	77.2
0	3	1	1150	0	61.3	56.7	66.7	79.5	66.05
0	5	0	1250	0	87.1	66.7	73.3	82.1	77.3
0	3	0	1260	0	83.9	60	56.7	76.9	69.38
0	1	1	900	0	48.4	63.3	43.3	53.8	52.2
0	3	1	1200	0	80.6	63.3	70	74.4	72.08
0	3	1	1190	1	77.4	80	60	87.2	76.15
0	0	1	1170	0	80.6	60	43.3	76.9	65.2
0	0	0	1180	0	90.3	86.7	73.3	82.1	83.1
0	0	1	1220	0	77.4	46.7	73.3	74.4	67.95
0	1	1	1010	0	71	66.7	66.7	76.9	70.33
0	0	0	1260	0	74.2	40	76.7	69.2	65.03
0	0	1	1280	0	80.6	46.7	70	69.2	66.63
0	0	1	1070	0	67.7	46.7	76.7	76.9	67
0	0	1	1070	1	96.8	86.7	86.7	76.9	86.78
0	3	1	1220	1	77.4	56.7	66.7	84.6	71.35
0	2	1	1110	0	61.3	66.7	63.3	74.4	66.43
0	3	1	1090	0	71	40	53.3	59	55.83
0	5	1	890	1	90.3	70	70	82.1	78.1

0	0	1	1350	0	71	76.7	90	92.3	82.5
0	0	0	1120	0	67.7	76.7	70	59	68.35
0	0	0	1050	0	77.4	56.7	63.3	56.4	63.45
0	0	1	1030	0	38.7	46.7	56.7	53.8	48.98
0	0	1	1070	0	71	40	66.7	71.8	62.38
0	0	1	1250	1	93.5	80	83.3	87.2	86
0	3	0	1340	0	71	80	70	69.2	72.55
0	5	0	1340	0	74.2	70	76.7	74.4	73.83
0	0	0	1150	1	87.1	76.7	86.7	76.9	81.85
0	3	1	1080	0	51.6	53.3	76.7	69.2	62.7
0	0	0	1150	0	77.4	50	50	59	59.1
0	2	0	800	0	77.4	56.7	80	76.9	72.75
0	2	1	920	0	71	50	90	74.4	71.35
0	5	0	1130	1	74.2	83.3	73.3	76.9	76.93
0	3	1	940	0	67.7	66.7	73.3	64.1	67.95
0	0	1	1300	0	71	53.3	60	79.5	65.95
0	1	1	970	0	67.7	40	63.3	59	57.5
0	1	1	1080	0	87.1	63.3	93.3	84.6	82.08
0	2	0	950	0	67.7	73.3	83.3	61.5	71.45
0	3	1	1100	0	83.9	60	70	84.6	74.63
0	3	0	1290	0	71	53.3	70	64.1	64.6
0	0	1	1020	0	71	43.3	66.7	74.4	63.85
0	5	1	1320	0	61.3	66.7	60	61.5	62.38
0	0	0	1000	0	74.2	60	60	74.4	67.15
0	0	1	1290	1	90.3	70	76.7	79.5	79.13
0	0	0	1200	0	77.4	43.3	40	61.5	55.55
0	2	0	1310	0	48.4	53.3	66.7	69.2	59.4
0	1	0	1120	0	58.1	26.7	73.3	59	54.28
0	1	0	1030	1	67.7	70	70	69.2	69.23
0	0	1	1450	0	96.8	86.7	90	89.7	90.8
0	0	1	1030	0	77.4	73.3	73.3	76.9	75.23
0	0	1	1190	0	77.4	63.3	86.7	74.4	75.45
0	0	1	1150	0	64.5	73.3	50	69.2	64.25
0	0	1	1100	0	77.4	76.7	66.7	82.1	75.73
0	0	1	1090	0	61.3	43.3	43.3	48.7	49.15
0	0	1	1150	0	61.3	46.7	46.7	71.8	56.63
0	1	1	940	0	67.7	63.3	83.3	71.8	71.53
0	3	1	1160	0	64.5	76.7	83.3	82.1	76.65
0	0	0	1150	0	83.9	63.3	56.7	71.8	68.93
0	0	1	1200	0	83.9	66.7	70	82.1	75.68
0	0	1	1160	0	64.5	60	66.7	74.4	66.4
0	1	1	1130	0	90.3	70	76.7	74.4	77.85
0	0	1	1130	0	83.9	60	66.7	76.9	71.88

0	5	0	1430	1	64.5	60	83.3	84.6	73.1
0	5	1	1000	1	64.5	43.3	53.3	61.5	55.65
0	0	1	1290	0	80.6	60	83.3	76.9	75.2
0	0	1	1120	0	80.6	46.7	60	74.4	65.43
0	0	1	1300	0	96.8	90	76.7	89.7	88.3
0	2	0	1150	0	71	73.3	76.7	74.4	73.85
0	0	1	1130	0	71	56.7	73.3	69.2	67.55
0	5	0	1150	0	77.4	43.3	66.7	64.1	62.88
0	5	1	1350	0	87.1	70	73.3	66.7	74.28
0	0	1	1280	0	74.2	53.3	83.3	76.9	71.93
0	0	0	1310	0	80.6	60	73.3	82.1	74
0	0	0	880	1	87.1	46.7	66.7	33.3	58.45
0	2	1	920	0	67.7	60	50	51.3	57.25
0	0	0	1070	1	71	53.3	80	71.8	69.03
0	0	1	1130	0	74.2	56.7	86.7	89.7	76.83
0	5	0	920	0	61.3	40	56.7	66.7	56.18
0	5	1	1110	0	74.2	40	63.3	74.4	62.98
0	5	1	1210	0	58.1	56.7	56.7	48.7	55.05
0	0	1	1140	0	71	66.7	73.3	76.9	71.98
0	0	0	1150	0	87.1	46.7	76.7	87.2	74.43
0	0	1	1150	0	61.3	76.7	73.3	74.4	71.43
0	0	1	1100	0	71	43.3	50	66.7	57.75
0	2	1	840	0	77.4	73.3	73.3	84.6	77.15
0	5	1	1320	0	77.4	46.7	66.7	79.5	67.58
0	0	1	1140	0	71	53.3	66.7	71.8	65.7
0	2	1	1020	0	74.2	43.3	63.3	79.5	65.08
0	0	1	1260	0	83.9	83.3	63.3	76.9	76.85
0	0	1	1160	1	90.3	73.3	70	66.7	75.08
0	0	0	1110	1	64.5	53.3	43.3	64.1	56.3
0	3	0	980	1	54.8	50	80	59	60.95
0	0	1	1020	0	54.8	50	80	59	60.95
0	0	0	1200	0	77.4	46.7	63.3	74.4	65.45
0	0	1	1410	0	74.2	70	80	82.1	76.58
0	4	1	1100	0	54.8	30	60	71.8	54.15
0	2	0	1060	0	61.3	73.3	70	61.5	66.53
0	2	0	1100	0	74.2	66.7	73.3	51.3	66.38
0	0	1	1140	0	80.6	30	46.7	66.7	56
0	3	0	1230	0	80.6	73.3	76.7	74.4	76.25
0	0	0	1310	0	90.3	76.7	70	87.2	81.05
0	1	1	820	0	74.2	63.3	70	74.4	70.48
0	0	0	990	1	87.1	76.7	83.3	84.6	82.93
0	0	0	1090	0	71	40	53.3	64.1	57.1
0	1	1	910	0	54.8	33.3	50	53.8	47.98

0	5	0	1280	0	77.4	80	86.7	84.6	82.18
0	2	1	1010	1	83.9	93.3	90	87.2	88.6
0	0	0	1240	0	90.3	56.7	83.3	74.4	76.18
0	0	0	1170	0	74.2	80	83.3	87.2	81.18
0	0	0	1220	0	67.7	56.7	66.7	84.6	68.93
0	0	1	1320	0	90.3	83.3	86.7	89.7	87.5
0	0	0	1170	1	90.3	73.3	80	79.5	80.78
0	1	1	1100	0	80.6	76.7	76.7	84.6	79.65
0	0	0	1210	1	87.1	73.3	80	92.3	83.18
0	0	0	1090	0	90.3	73.3	73.3	71.8	77.18
0	5	0	1350	0	67.7	46.7	63.3	69.2	61.73
0	5	1	1030	0	80.6	53.3	80	87.2	75.28
0	3	0	1060	0	87.1	66.7	83.3	87.2	81.08
0	0	0	1270	0	77.4	53.3	86.7	76.9	73.58
0	0	0	1190	0	90.3	73.3	83.3	87.2	83.53
0	5	1	1360	0	80.6	50	66.7	76.9	68.55
0	2	0	800	0	38.7	56.7	66.7	69.2	57.83
0	0	0	1030	0	51.6	43.3	83.3	84.6	65.7
0	0	1	1190	0	77.4	43.3	76.7	84.6	70.5
0	3	1	1200	0	67.7	66.7	80	69.2	70.9
0	1	1	1150	0	61.3	46.7	60	74.4	60.6
0	5	1	1320	0	83.9	70	80	79.5	78.35
0	0	0	1360	0	77.4	46.7	83.3	76.9	71.08
0	5	1	1080	1	71	80	80	89.7	80.18
0	0	1	910	0	51.6	63.3	63.3	71.8	62.5
0	1	1	920	0	71	60	76.7	61.5	67.3
0	1	1	1120	0	74.2	40	60	66.7	60.23
0	0	1	1120	0	71	63.3	76.7	59	67.5
0	5	0	1220	0	93.5	73.3	86.7	61.5	78.75
0	0	1	1100	0	77.4	76.7	86.7	89.7	82.63
0	5	1	910	0	61.3	36.7	43.3	51.3	48.15
0	5	0	1400	0	90.3	76.7	86.7	92.3	86.5
0	0	1	1130	0	71	63.3	56.7	82.1	68.28
0	1	0	1060	0	71	76.7	66.7	69.2	70.9
0	0	1	1370	0	71	53.3	70	69.2	65.88
0	0	1	1200	0	87.1	63.3	60	82.1	73.13
0	0	0	1300	0	77.4	83.3	70	66.7	74.35
0	1	1	1070	1	83.9	70	90	82.1	81.5
0	5	1	1010	1	83.9	60	80	76.9	75.2
0	1	0	1040	0	83.9	83.3	63.3	69.2	74.93
0	2	1	1000	0	48.4	36.7	86.7	59	57.7
0	1	1	1240	0	77.4	83.3	76.7	94.9	83.08
0	0	1	1350	0	67.7	56.7	50	35.9	52.58

0	0	1	1260	0	90.3	66.7	86.7	84.6	82.08
0	0	1	990	0	67.7	50	60	61.5	59.8
0	5	0	1260	1	87.1	53.3	70	71.8	70.55
0	0	0	1100	0	87.1	56.7	63.3	82.1	72.3
0	0	1	1180	0	87.1	63.3	90	84.6	81.25
0	5	0	1020	1	83.9	66.7	70	76.9	74.38
0	5	1	1150	0	83.9	66.7	70	82.1	75.68
0	2	1	870	0	41.9	30	56.7	28.2	39.2
0	5	1	1280	0	67.7	50	66.7	64.1	62.13
0	0	0	1310	0	96.8	86.7	86.7	87.2	89.35
0	0	1	1280	1	74.2	40	73.3	69.2	64.18
1	0	0	1380	0	66.7	93.5	57.5	76.9	73.65
1	0	1	1250	0	56.7	67.7	67.5	61.5	63.35
1	0	0	1280	0	83.3	71	65	79.5	74.7
1	1	1	1070	0	73.3	74.2	62.5	69.2	69.8
1	2	1	1250	1	83.3	80.6	55	84.6	75.88
1	0	1	1150	1	73.3	83.9	55	76.9	72.28
1	0	0	1140	1	73.3	80.6	55	51.3	65.05
1	2	1	1070	1	70	87.1	52.5	71.8	70.35
1	0	1	1130	0	73.3	87.1	65	76.9	75.58
1	0	0	1310	0	80	80.6	65	66.7	73.08
1	2	1	970	0	60	61.3	52.5	64.1	59.48
1	0	1	1120	0	66.7	77.4	52.5	66.7	65.83
1	3	0	960	1	33.3	51.6	60	59	50.98
1	0	1	1330	0	80	64.5	45	56.4	61.48
1	0	1	830	0	56.7	58.1	45	51.3	52.78
1	0	1	1120	0	76.7	83.9	50	76.9	71.88
1	0	0	1480	0	83.3	61.3	55	84.6	71.05
1	1	1	1210	0	60	71	35	48.7	53.68
1	1	1	970	0	76.7	71	37.5	53.8	59.75
1	2	1	1200	1	83.3	80.6	47.5	53.8	66.3
1	0	0	1310	1	76.7	74.2	62.5	87.2	75.15
1	0	0	1220	0	76.7	77.4	55	66.7	68.95
1	2	1	820	0	60	51.6	40	43.6	48.8
1	3	1	1100	0	90	74.2	62.5	76.9	75.9
1	0	1	1150	0	86.7	90.3	57.5	79.5	78.5
1	2	1	850	0	73.3	64.5	30	59	56.7
1	0	1	1090	0	60	74.2	62.5	79.5	69.05
1	0	0	1350	0	76.7	71	50	69.2	66.73
1	0	0	1170	1	66.7	77.4	65	74.4	70.88
1	0	1	1250	1	73.3	74.2	62.5	74.4	71.1
1	2	1	1070	0	66.7	54.8	42.5	53.8	54.45
1	0	1	1000	0	63.3	54.8	40	59	54.28

1	2	0	980	0	73.3	67.7	55	66.7	65.68
1	5	0	1200	0	70	67.7	52.5	59	62.3
1	5	1	1090	0	66.7	54.8	40	79.5	60.25
1	5	1	1380	0	96.7	87.1	62.5	79.5	81.45
1	0	1	1370	0	83.3	100	70	89.7	85.75
1	3	1	1090	0	60	67.7	45	56.4	57.28
1	1	0	950	0	86.7	80.6	52.5	66.7	71.63
1	5	1	1220	0	73.3	58.1	52.5	59	60.73
1	0	0	1260	0	73.3	80.6	57.5	74.4	71.45
1	1	0	860	0	63.3	58.1	60	76.9	64.58
1	0	1	1330	0	80	74.2	50	74.4	69.65
1	1	1	960	0	73.3	58.1	37.5	59	56.98
1	0	1	1240	0	83.3	96.8	65	89.7	83.7
1	3	0	1260	1	86.7	61.3	55	82.1	71.28
1	1	1	950	0	53.3	54.8	50	61.5	54.9
1	5	1	1150	0	76.7	67.7	57.5	61.5	65.85
1	5	1	1160	0	70	77.4	52.5	59	64.73
1	0	0	1080	0	66.7	74.2	55	66.7	65.65
1	0	1	1340	0	80	58.1	60	76.9	68.75
1	0	1	1080	0	70	74.2	62.5	76.9	70.9
1	1	1	1050	0	63.3	64.5	52.5	69.2	62.38
1	0	1	1200	1	73.3	80.6	45	71.8	67.68
1	5	1	1360	0	86.7	80.6	70	84.6	80.48
1	0	0	1160	1	70	90.3	65	79.5	76.2
1	0	0	1160	0	90	58.1	65	59	68.03
1	0	0	1140	1	80	74.2	70	76.9	75.28
1	0	0	1260	0	63.3	64.5	45	64.1	59.23
1	0	0	1140	0	90	80.6	55	64.1	72.43
1	0	0	1210	0	63.3	67.7	50	51.3	58.08
1	0	1	1300	0	63.3	58.1	52.5	64.1	59.5
1	2	1	900	1	60	54.8	42.5	46.2	50.88
1	0	1	1090	0	56.7	74.2	50	74.4	63.83
1	0	1	1270	0	90	87.1	50	69.2	74.08
1	0	1	1230	0	90	83.9	65	71.8	77.68
1	0	1	1270	0	70	74.2	57.5	84.6	71.58
1	5	1	1070	0	60	80.6	65	82.1	71.93
1	0	1	1120	0	70	77.4	62.5	76.9	71.7
1	0	1	1080	0	70	58.1	57.5	51.3	59.23
1	0	0	1170	0	73.3	64.5	67.5	76.9	70.55
1	2	1	1240	0	90	77.4	60	64.1	72.88
1	0	1	1130	0	76.7	87.1	65	79.5	77.08
1	0	0	1230	0	63.3	71	40	66.7	60.25
1	1	1	1320	0	86.7	80.6	60	69.2	74.13

1	0	1	1260	0	80	74.2	55	71.8	70.25
1	3	1	1190	0	76.7	67.7	50	71.8	66.55
1	1	0	1150	0	86.7	67.7	45	74.4	68.45
1	0	1	1300	0	86.7	93.5	72.5	94.9	86.9
1	1	1	860	0	76.7	83.9	60	71.8	73.1
1	3	1	1220	1	66.7	80.6	65	89.7	75.5
1	1	1	970	1	80	96.8	60	66.7	75.88
1	0	1	1260	0	86.7	77.4	70	92.3	81.6
1	1	1	990	1	73.3	90.3	70	69.2	75.7
1	0	1	1110	0	80	67.7	55	76.9	69.9
1	0	0	1350	0	76.7	74.2	55	74.4	70.08
1	0	1	1370	1	100	100	70	97.4	91.85
1	0	1	1260	0	73.3	45.2	52.5	71.8	60.7
1	0	0	1230	0	86.7	90.3	65	87.2	82.3
1	0	0	1200	0	73.3	80.6	67.5	79.5	75.23
1	1	1	1060	0	56.7	61.3	47.5	59	56.13
1	0	0	1220	1	76.7	74.2	65	64.1	70
1	2	1	1160	0	83.3	77.4	65	74.4	75.03
1	2	0	1110	0	66.7	35.5	47.5	56.4	51.53
1	0	0	1200	0	90	67.7	55	74.4	71.78
1	0	0	1120	0	70	64.5	47.5	66.7	62.18
1	0	1	1200	0	83.3	64.5	45	66.7	64.88
1	0	1	1120	0	90	77.4	62.5	74.4	76.08
1	0	1	1240	0	93.3	80.6	72.5	74.4	80.2
1	3	1	1230	0	93.3	80.6	67.5	79.5	80.23
1	0	1	1220	0	86.7	96.8	60	84.6	82.03
1	0	0	1410	0	76.7	64.5	45	79.5	66.43
1	0	1	1260	0	76.7	64.5	57.5	64.1	65.7
1	2	1	1090	1	56.7	67.7	42.5	51.3	54.55
1	5	1	1120	0	73.3	83.9	62.5	71.8	72.88
1	2	1	970	0	80	87.1	62.5	82.1	77.93
1	2	0	870	1	63.3	38.7	50	61.5	53.38
1	1	1	1030	0	76.7	64.5	57.5	59	64.43
1	5	0	1420	1	90	90.3	72.5	97.4	87.55
1	1	1	1090	0	56.7	71	67.5	66.7	65.48
1	1	1	980	0	53.3	64.5	47.5	53.8	54.78
1	3	1	1290	0	90	64.5	55	66.7	69.05
1	0	1	1160	0	83.3	83.9	55	79.5	75.43
1	0	1	1080	1	70	74.2	55	69.2	67.1
1	2	1	1030	1	70	64.5	52.5	59	61.5
1	5	1	1380	0	86.7	77.4	50	76.9	72.75
1	0	1	1140	0	83.3	74.2	55	61.5	68.5
1	5	1	1270	0	73.3	74.2	70	87.2	76.18

1	0	1	1350	0	76.7	74.2	42.5	64.1	64.38
1	2	1	860	0	56.7	64.5	47.5	46.2	53.73
1	0	1	1210	0	93.3	83.9	62.5	92.3	83
1	0	0	1320	0	86.7	77.4	60	56.4	70.13
1	0	1	1230	0	83.3	80.6	57.5	74.4	73.95
1	1	1	1190	0	70	61.3	55	59	61.33
1	0	1	1240	0	76.7	74.2	45	53.8	62.43
1	1	1	1110	1	70	64.5	55	79.5	67.25
1	0	1	1230	1	83.3	90.3	70	82.1	81.43
1	0	1	1140	1	73.3	87.1	70	74.4	76.2
1	0	1	1150	0	70	77.4	62.5	66.7	69.15
1	0	1	1230	0	80	64.5	57.5	74.4	69.1
1	5	1	1210	0	86.7	83.9	70	87.2	81.95
1	0	1	1130	1	83.3	80.6	60	66.7	72.65
1	0	1	1170	0	80	77.4	57.5	84.6	74.88
1	1	1	980	0	63.3	74.2	42.5	61.5	60.38
1	0	1	1230	0	83.3	67.7	52.5	64.1	66.9
1	0	0	1200	0	63.3	45.2	50	53.8	53.08
1	0	1	1170	0	90	87.1	70	82.1	82.3
1	5	1	1180	1	83.3	83.9	67.5	79.5	78.55
1	0	1	1080	0	63.3	67.7	35	61.5	56.88
1	2	1	1030	1	73.3	77.4	55	66.7	68.1
1	0	1	1280	0	76.7	90.3	62.5	84.6	78.53
1	2	1	970	0	80	64.5	50	64.1	64.65
1	2	1	1240	0	70	90.3	52.5	84.6	74.35
1	0	1	1090	0	80	51.6	55	74.4	65.25
1	0	0	1240	0	90	77.4	55	64.1	71.63
1	3	1	1160	0	73.3	77.4	47.5	69.2	66.85
1	0	1	1050	1	70	74.2	50	61.5	63.93
1	0	1	950	0	43.3	45.2	45	41	43.63
1	5	0	1110	0	83.3	83.9	60	71.8	74.75
1	0	1	1100	0	76.7	80.6	55	69.2	70.38
1	0	1	1420	0	90	90	93.3	87.5	90.2
1	0	0	1470	0	83.3	96.7	80	85	86.25
1	0	1	1190	0	96.7	96.7	93.3	92.5	94.8
1	0	1	1460	0	83.3	86.7	73.3	62.5	76.45
1	0	1	1190	0	93.3	73.3	83.3	77.5	81.85
1	0	1	1270	0	70	86.7	76.7	60	73.35
1	1	0	1000	0	70	56.7	73.3	52.5	63.13
1	0	1	1060	1	76.7	80	86.7	77.5	80.23
1	5	1	1230	0	73.3	76.7	80	82.5	78.13
1	4	1	1120	0	93.3	73.3	90	75	82.9
1	0	1	1010	0	46.7	53.3	53.3	55	52.08

1	0	1	1280	0	63.3	70	73.3	65	67.9
1	0	0	1400	1	93.3	93.3	86.7	90	90.83
1	5	1	1120	0	66.7	83.3	90	55	73.75
1	0	0	1150	0	56.7	63.3	76.7	52.5	62.3
1	0	1	1140	0	80	86.7	80	67.5	78.55
1	1	1	1200	0	53.3	76.7	73.3	65	67.08
1	0	0	920	0	70	76.7	83.3	72.5	75.63
1	1	1	890	1	63.3	76.7	56.7	35	57.93
1	2	1	810	0	80	56.7	66.7	65	67.1
1	0	1	1230	1	73.3	53.3	63.3	62.5	63.1
1	1	1	1040	1	66.7	73.3	73.3	75	72.08
1	0	1	1120	1	86.7	83.3	76.7	75	80.43
1	5	1	1040	0	86.7	83.3	86.7	82.5	84.8
1	0	0	1160	0	66.7	76.7	73.3	55	67.93
1	3	1	1130	0	73.3	80	60	57.5	67.7
1	0	1	1290	0	80	80	90	77.5	81.88
1	3	1	1220	0	66.7	63.3	73.3	60	65.83
1	2	0	830	0	56.7	56.7	63.3	77.5	63.55
1	2	1	1020	0	50	60	70	45	56.3
1	2	1	1100	0	46.7	73.3	76.7	72.5	67.3
1	3	1	900	0	66.7	50	50	35	50.43
1	0	1	1090	1	76.7	80	70	77.5	76.05
1	0	0	1250	0	76.7	86.7	83.3	82.5	82.3
1	0	0	1310	0	73.3	76.7	83.3	75	77.08
1	5	0	1010	0	80	73.3	86.7	65	76.25
1	3	1	1310	1	66.7	76.7	63.3	45	62.93
1	1	1	1060	0	43.3	63.3	66.7	60	58.33
1	2	0	1110	1	70	80	70	62.5	70.63
1	2	1	1060	0	60	83.3	80	67.5	72.7
1	0	1	1180	0	70	76.7	63.3	67.5	69.38
1	0	1	1110	0	73.3	76.7	70	57.5	69.38
1	2	1	980	1	66.7	76.7	73.3	72.5	72.3
1	0	1	1360	0	90	76.7	96.7	85	87.1
1	5	1	1030	1	73.3	80	66.7	72.5	73.13
1	5	1	950	0	76.7	73.3	80	65	73.75
1	0	1	1090	1	73.3	83.3	90	77.5	81.03
1	3	1	1030	0	66.7	73.3	76.7	62.5	69.8
1	0	1	1250	0	80	86.7	70	67.5	76.05
1	2	1	1090	0	83.3	93.3	86.7	85	87.08
1	0	1	1210	0	70	66.7	66.7	65	67.1
1	5	1	1280	0	60	63.3	70	55	62.08
1	1	1	970	0	53.3	66.7	70	45	58.75
1	5	1	1000	0	70	66.7	83.3	70	72.5

1	0	0	1140	1	80	93.3	83.3	70	81.65
1	0	0	1120	0	53.3	83.3	66.7	75	69.58
1	5	1	1240	1	70	86.7	80	80	79.18
1	3	0	1250	0	70	50	70	70	65
1	0	1	1270	0	80	80	90	77.5	81.88
1	0	1	1130	0	76.7	76.7	83.3	77.5	78.55
1	0	1	1380	0	70	76.7	80	75	75.43
1	1	0	870	0	73.3	83.3	73.3	60	72.48
1	0	1	1090	0	53.3	73.3	63.3	80	67.48
1	3	1	1160	0	70	70	66.7	57.5	66.05
1	0	1	1310	1	86.7	90	93.3	85	88.75
1	1	0	1070	0	66.7	76.7	73.3	50	66.68
1	0	1	1210	0	66.7	63.3	63.3	40	58.33
1	0	1	1220	1	83.3	70	76.7	80	77.5
1	3	1	1420	1	80	96.7	83.3	85	86.25
1	0	1	1100	1	73.3	90	90	87.5	85.2
1	3	1	940	0	70	76.7	70	67.5	71.05
1	0	0	1270	0	63.3	70	60	65	64.58
1	2	1	960	0	43.3	50	83.3	52.5	57.28
1	2	1	990	0	76.7	76.7	56.7	57.5	66.9
1	0	1	1220	1	93.3	93.3	80	90	89.15
1	0	0	1120	0	66.7	46.7	60	45	54.6
1	0	1	1220	0	86.7	73.3	76.7	70	76.68
1	0	0	1330	0	83.3	73.3	66.7	80	75.83
1	0	1	1070	0	80	66.7	76.7	75	74.6
1	0	1	1180	0	73.3	76.7	80	70	75
1	0	1	1180	0	76.7	86.7	66.7	57.5	71.9
1	2	0	990	0	63.3	70	80	62.5	68.95
1	5	0	1260	1	46.7	56.7	60	57.5	55.23
1	1	1	1070	0	66.7	66.7	73.3	57.5	66.05
1	2	1	1160	0	80	73.3	80	82.5	78.95
1	0	0	1330	0	86.7	70	83.3	75	78.75
1	2	0	1010	0	50	46.7	46.7	37.5	45.23
1	0	1	1130	1	93.3	83.3	93.3	85	88.73
1	3	0	1160	1	80	66.7	90	82.5	79.8
1	0	1	1160	0	73.3	73.3	90	82.5	79.78
1	2	1	1190	1	86.7	83.3	73.3	65	77.08
1	0	1	1250	0	83.3	63.3	70	55	67.9
1	0	0	1000	1	70	63.3	76.7	65	68.75
1	0	0	1350	1	60	83.3	60	72.5	68.95
1	3	1	1390	0	80	76.7	86.7	70	78.35
1	0	0	1170	1	76.7	66.7	76.7	52.5	68.15
1	0	1	1100	0	63.3	63.3	80	60	66.65

1	5	0	1080	1	66.7	53.3	80	65	66.25
1	0	1	1100	0	73.3	76.7	70	55	68.75
1	0	1	1250	0	83.3	90	90	72.5	83.95
1	0	1	1230	1	63.3	93.3	93.3	70	79.98
1	0	1	1110	0	80	66.7	63.3	77.5	71.88
1	0	1	1250	0	76.7	80	70	72.5	74.8
1	2	1	900	0	70	80	70	67.5	71.88
1	2	1	1050	0	76.7	60	76.7	60	68.35
1	2	1	1110	0	86.7	76.7	76.7	75	78.78
1	2	0	1060	0	70	66.7	56.7	52.5	61.48
1	0	0	1170	0	80	76.7	76.7	77.5	77.73
1	0	1	940	0	83.3	73.3	80	87.5	81.03
1	2	1	1110	0	76.7	76.7	80	75	77.1
1	1	1	1120	1	86.7	93.3	70	77.5	81.88
1	0	1	1330	0	83.3	80	93.3	72.5	82.28
1	1	0	1000	1	60	80	80	70	72.5
1	5	0	1030	0	66.7	83.3	93.3	72.5	78.95
1	1	0	1120	1	56.7	53.3	40	52.5	50.63
1	2	1	1010	0	76.7	86.7	76.7	65	76.28
1	0	1	1440	0	76.7	80	80	60	74.18
1	0	1	1110	1	76.7	60	80	72.5	72.3
1	5	1	1140	1	86.7	83.3	86.7	77.5	83.55
1	3	1	1030	0	66.7	70	60	45	60.43
1	0	0	1060	1	83.3	90	86.7	90	87.5
1	0	1	1340	0	76.7	76.7	73.3	67.5	73.55
1	2	1	1090	0	73.3	83.3	80	75	77.9
1	0	1	1080	0	80	70	83.3	82.5	78.95
1	1	1	1070	1	56.7	63.3	60	47.5	56.88
1	3	1	1140	0	66.7	66.7	73.3	57.5	66.05
1	1	1	1000	1	70	70	76.7	67.5	71.05
1	0	0	1300	0	80	60	70	80	72.5
1	0	0	1040	0	56.7	70	50	67.5	61.05
1	1	1	1170	0	50	70	63.3	62.5	61.45
1	3	1	1160	1	83.3	80	93.3	80	84.15
1	1	0	1190	1	56.7	73.3	66.7	72.5	67.3
1	0	1	1340	0	83.3	83.3	90	77.5	83.53
1	0	0	1100	0	60	56.7	80	60	64.18
1	0	0	1150	0	80	60	53.3	62.5	63.95
1	1	0	1060	0	60	56.7	66.7	70	63.35
1	0	0	1200	0	60	80	90	67.5	74.38
1	0	1	1220	0	80	60	93.3	85	79.58
1	0	1	1240	0	70	90	83.3	72.5	78.95
1	0	1	1030	0	76.7	63.3	60	60	65

1	5	0	1150	0	76.7	73.3	80	77.5	76.88
1	2	1	1030	1	80	86.7	93.3	82.5	85.63
1	0	1	1180	0	73.3	80	80	60	73.33
1	0	0	1150	0	56.7	63.3	83.3	65	67.08
1	0	1	1210	0	73.3	46.7	80	62.5	65.63
1	0	0	1400	0	70	83.3	80	72.5	76.45
1	3	1	1070	1	76.7	66.7	86.7	85	78.78
1	1	1	890	0	63.3	43.3	66.7	32.5	51.45
1	3	1	1240	0	70	83.3	60	65	69.58
1	0	1	1170	0	56.7	70	63.3	52.5	60.63
1	3	0	1220	0	73.3	73.3	60	72.5	69.78
1	0	1	1290	0	76.7	70	70	72.5	72.3
1	0	1	1320	0	73.3	76.7	90	62.5	75.63
1	0	1	1290	1	93.3	80	76.7	90	85
1	0	1	1180	0	70	70	63.3	77.5	70.2
1	0	1	1130	0	73.3	83.3	86.7	70	78.33
1	0	0	1130	0	90	93.3	90	87.5	90.2
1	2	1	1080	0	66.7	53.3	63.3	70	63.33
1	1	1	1040	0	86.7	96.7	83.3	77.5	86.05
1	2	1	1030	1	76.7	73.3	60	62.5	68.13
1	0	1	1050	0	80	83.3	76.7	75	78.75
1	3	0	1290	1	83.3	83.3	86.7	67.5	80.2
1	4	1	1250	0	70	66.7	73.3	57.5	66.88
1	2	1	1030	0	70	83.3	73.3	75	75.4
1	0	1	1160	0	66.7	80	70	72.5	72.3
1	5	1	1250	0	66.7	80	73.3	70	72.5
1	3	1	1170	1	80	90	80	70	80
1	1	1	1070	0	90	70	73.3	62.5	73.95
1	5	1	1440	0	83.3	86.7	80	80	82.5
1	5	1	1150	0	76.7	93.3	90	77.5	84.38
1	0	0	1160	0	73.3	66.7	50	67.5	64.38
1	0	1	1080	0	66.7	63.3	76.7	50	64.18
1	1	1	860	0	40	43.3	50	47.5	45.2
1	0	1	1200	1	66.7	76.7	66.7	80	72.53
1	0	1	1230	0	90	80	80	90	85
1	1	0	1240	0	86.7	60	86.7	82.5	78.98
1	0	1	1200	0	83.3	96.7	83.3	82.5	86.45
1	0	1	1210	0	73.3	73.3	73.3	57.5	69.35
1	3	1	1390	0	70	90	76.7	72.5	77.3
1	5	1	990	0	66.7	66.7	80	62.5	68.98
1	0	1	1370	0	76.7	63.6	76.7	73.6	72.65
1	0	0	1060	0	63.3	66.7	66.7	56.6	63.33
1	0	0	1130	0	70	63.6	73.3	67.9	68.7

1	5	1	1330	1	90	63.6	80	84.9	79.63
1	1	1	810	0	63.3	51.5	56.7	35.8	51.83
1	3	1	1130	0	63.3	42.4	56.7	60.4	55.7
1	0	1	1230	0	70	63.6	90	71.7	73.83
1	0	1	1250	0	70	63.6	90	75.5	74.78
1	1	1	1040	0	73.3	60.6	83.3	75.5	73.18
1	0	1	1150	0	90	63.6	83.3	94.3	82.8
1	0	1	1140	1	80	84.8	76.7	64.2	76.43
1	3	1	1240	0	80	66.7	63.3	62.3	68.08
1	0	1	1200	0	66.7	54.5	93.3	64.2	69.68
1	3	1	1420	0	96.7	87.9	96.7	92.5	93.45
1	2	0	840	1	40	57.6	60	50.9	52.13
1	3	1	1170	0	76.7	69.7	76.7	86.8	77.48
1	0	0	1150	1	83.3	45.5	76.7	79.2	71.18
1	3	1	1020	0	66.7	60.6	70	64.2	65.38
1	0	1	1180	0	83.3	57.6	76.7	73.6	72.8
1	1	1	860	0	60	63.6	76.7	69.8	67.53
1	1	1	1300	0	76.7	78.8	90	79.2	81.18
1	0	0	1200	0	66.7	60.6	60	58.5	61.45
1	3	0	1180	0	73.3	54.5	60	62.3	62.53
1	0	1	1350	0	90	66.7	86.7	79.2	80.65
1	0	1	1200	1	90	87.9	93.3	88.7	89.98
1	1	1	1150	0	86.7	66.7	86.7	79.2	79.83
1	1	1	1100	0	90	78.8	80	71.7	80.13
1	3	1	1130	0	53.3	63.6	53.3	49.1	54.83
1	1	0	970	1	46.7	78.8	90	67.9	70.85
1	4	1	820	0	33.3	33.3	50	49.1	41.43
1	0	1	1210	0	93.3	75.8	86.7	67.9	80.93
1	0	1	1170	0	93.3	72.7	73.3	58.5	74.45
1	0	1	1170	0	83.3	72.7	76.7	73.6	76.58
1	2	0	840	1	70	66.7	70	64.2	67.73
1	0	0	1070	1	60	54.5	70	67.9	63.1
1	2	1	980	0	70	39.4	76.7	60.4	61.63
1	0	1	1230	0	80	57.6	80	64.2	70.45
1	0	1	1290	1	90	84.8	90	79.2	86
1	1	1	870	0	73.3	81.8	76.7	67.9	74.93
1	0	1	1260	0	83.3	75.8	83.3	67.9	77.58
1	0	1	1060	0	73.3	63.6	70	71.7	69.65
1	0	1	1100	0	60	63.6	80	52.8	64.1
1	0	1	1050	0	80	48.5	76.7	64.2	67.35
1	3	1	1340	0	70	63.6	80	71.7	71.33
1	0	0	1020	0	50	48.5	80	50.9	57.35
1	2	1	1080	0	70	54.5	73.3	50.9	62.18

1	0	1	1180	0	63.3	72.7	83.3	58.5	69.45
1	0	1	1190	0	73.3	81.8	90	67.9	78.25
1	0	0	1300	0	63.3	75.8	86.7	64.2	72.5
1	0	1	1330	0	80	66.7	83.3	83	78.25
1	0	1	1350	0	90	78.8	90	83	85.45
1	5	1	1140	1	86.7	78.8	76.7	69.8	78
1	0	0	1150	0	80	78.8	90	75.5	81.08
1	0	1	1320	0	93.3	72.7	86.7	79.2	82.98
1	0	1	1110	0	70	69.7	70	60.4	67.53
1	1	1	1050	1	60	51.5	63.3	58.5	58.33
1	0	0	1100	0	83.3	84.8	83.3	79.2	82.65
1	0	1	1300	0	86.7	78.8	93.3	77.4	84.05
1	0	1	1030	1	83.3	66.7	70	52.8	68.2
1	5	1	1290	0	86.7	81.8	73.3	77.4	79.8
1	3	1	1190	0	86.7	75.8	80	66	77.13
1	0	1	1290	0	80	60.6	83.3	54.7	69.65
1	0	1	1120	0	53.3	63.6	53.3	39.6	52.45
1	0	0	1330	0	73.3	69.7	90	66	74.75
1	0	1	1250	0	63.3	48.5	66.7	54.7	58.3
1	1	1	820	0	53.3	54.5	70	47.2	56.25
1	0	0	1260	0	83.3	72.7	80	73.6	77.4
1	3	1	1240	0	70	72.7	76.7	60.4	69.95
1	0	1	1250	0	63.3	75.8	86.7	56.6	70.6
1	2	1	940	1	63.3	69.7	86.7	73.6	73.33
1	1	1	1030	0	90	69.7	93.3	84.9	84.48
1	0	1	1270	0	80	63.6	73.3	69.8	71.68
1	0	1	1140	1	60	81.8	80	66	71.95
1	5	1	1080	1	70	72.7	86.7	79.2	77.15
1	3	1	1370	0	96.7	87.9	80	71.7	84.08
1	3	1	1250	0	76.7	69.7	80	69.8	74.05
1	0	1	1340	0	76.7	78.8	90	69.8	78.83
1	2	1	1140	0	73.3	69.7	80	69.8	73.2
1	0	0	1240	0	83.3	60.6	80	73.6	74.38
1	1	0	1120	0	86.7	75.8	80	79.2	80.43
1	5	1	1200	1	73.3	69.7	76.7	66	71.43
1	0	1	1150	0	73.3	51.5	80	66	67.7
1	0	1	1250	0	80	81.8	83.3	79.2	81.08
1	0	0	1190	1	83.3	81.8	76.7	60.4	75.55
1	1	0	1200	0	76.7	75.8	73.3	64.2	72.5
1	0	0	1220	1	83.3	69.7	80	66	74.75
1	0	1	1220	0	70	81.8	96.7	66	78.63
1	0	1	1020	0	63.3	51.5	63.3	60.4	59.63
1	1	1	870	0	66.7	57.6	80	77.4	70.43

1	1	0	970	1	60	57.6	76.7	67.9	65.55
1	0	0	1170	0	66.7	69.7	80	64.2	70.15
1	0	0	1370	0	76.7	48.5	83.3	64.2	68.18
1	2	1	1070	0	50	51.5	60	56.6	54.53
1	2	1	1060	0	70	54.5	83.3	66	68.45
1	0	0	1330	0	73.3	69.7	86.7	64.2	73.48
1	0	1	1230	0	83.3	72.7	80	79.2	78.8
1	5	0	950	0	63.3	48.5	60	50.9	55.68
1	3	1	1220	0	66.7	66.7	76.7	69.8	69.98
1	0	1	1240	0	70	72.7	83.3	79.2	76.3
1	0	1	830	0	50	48.5	66.7	54.7	54.98
1	0	1	1160	0	76.7	69.7	90	67.9	76.08
1	1	1	890	0	86.7	60.6	83.3	58.5	72.28
1	0	0	1130	0	76.7	81.8	90	71.7	80.05
1	5	0	1070	0	56.7	45.5	63.3	37.7	50.8
1	0	0	1250	0	76.7	63.6	73.3	58.5	68.03
1	0	1	1170	1	83.3	63.6	76.7	66	72.4
1	1	1	990	1	70	75.8	80	73.6	74.85
1	0	0	1340	0	76.7	60.6	66.7	62.3	66.58
1	5	1	1020	0	70	72.7	73.3	64.2	70.05
1	2	1	1200	1	86.7	84.8	83.3	79.2	83.5
1	1	1	1210	0	83.3	78.8	76.7	71.7	77.63
1	0	1	1200	0	66.7	60.6	80	71.7	69.75
1	0	1	1210	1	73.3	72.7	83.3	77.4	76.68
1	1	1	1130	1	86.7	97	96.7	96.2	94.15
1	1	1	850	0	90	81.8	90	77.4	84.8
1	0	1	1280	0	76.7	69.7	70	67.9	71.08
1	1	0	1100	0	63.3	87.9	66.7	67.9	71.45
1	3	1	1190	0	90	69.7	93.3	81.1	83.53
1	0	0	1140	0	83.3	45.5	76.7	60.4	66.48
1	2	1	1000	1	80	78.8	86.7	71.7	79.3
1	0	0	1410	1	63.3	66.7	80	79.2	72.3
1	1	1	920	0	66.7	51.5	80	75.5	68.43
1	3	1	1110	0	90	78.8	83.3	69.8	80.48
1	2	1	1080	0	70	81.8	86.7	66	76.13
1	1	1	1160	0	80	60.6	80	69.8	72.6
1	1	0	1160	0	76.7	72.7	80	69.8	74.8
1	0	1	1270	0	83.3	75.8	76.7	79.2	78.75
1	0	1	950	0	40	75.8	76.7	67.9	65.1
1	3	1	1020	1	90	75.8	100	79.2	86.25
1	2	1	970	0	86.7	81.8	76.7	60.4	76.4
1	3	0	1020	1	80	78.8	80	62.3	75.28
1	0	1	1200	0	83.3	72.7	86.7	75.5	79.55

1	0	0	1090	0	60	48.5	83.3	64.2	64
1	0	1	1270	1	80	69.7	93.3	67.9	77.73
1	2	1	940	0	83.3	75.8	73.3	75.5	76.98
1	0	1	1170	0	76.7	84.8	86.7	66	78.55
1	1	1	1180	0	80	72.7	90	67.9	77.65
1	1	0	1030	0	90	72.7	73.3	62.3	74.58
1	0	1	1180	0	80	72.7	90	73.6	79.08
1	0	1	1360	0	86.7	87.9	76.7	69.8	80.28
1	0	1	1090	0	90	78.8	93.3	79.2	85.33
1	4	1	1290	0	70	63.6	76.7	66	69.08
1	2	1	1300	0	86.7	81.8	80	64.2	78.18
1	0	1	1030	0	66.7	60.6	73.3	66	66.65
1	0	1	1190	0	86.7	72.7	83.3	79.2	80.48
1	2	1	810	0	53.3	66.7	93.3	83	74.08
1	0	1	1000	0	60	72.7	90	66	72.18
1	0	1	1150	0	66.7	60.6	76.7	49.1	63.28
1	0	1	1020	0	60	54.5	50	34	49.63
1	1	1	1100	0	53.3	36.4	60	56.6	51.58
1	0	1	1080	0	63.3	54.5	80	64.2	65.5
1	3	0	1030	1	83.3	78.8	63.3	66	72.85
1	0	0	920	0	56.7	48.5	86.7	62.3	63.55
1	0	1	1150	0	90	87.9	93.3	90.6	90.45
1	3	1	970	0	76.7	60.6	66.7	52.8	64.2
1	0	1	1110	1	90	75.8	90	86.8	85.65
1	0	0	1120	0	70	39.4	66.7	64.2	60.08
1	5	1	1230	0	90	93.9	90	90.6	91.13
1	0	0	1350	0	76.7	78.8	83.3	81.1	79.98
1	2	1	1160	0	73.3	45.5	80	64.2	65.75
1	0	1	1250	1	76.7	84.8	73.3	79.2	78.5
1	2	1	890	0	56.7	57.6	73.3	56.6	61.05
1	0	0	990	1	90	81.8	80	66	79.45
1	0	1	1250	0	93.3	60.6	73.3	77.4	76.15
1	0	1	1090	1	83.3	87.9	90	79.2	85.1
1	0	0	1290	0	83.3	75.8	83.3	71.7	78.53
1	1	1	980	0	83.3	69.7	83.3	60.4	74.18
1	2	1	970	0	60	63.6	63.3	62.3	62.3
1	1	0	1040	0	73.3	66.7	80	54.7	68.68
1	0	0	1350	0	76.7	75.8	76.7	69.8	74.75
1	0	0	1050	0	63.3	45.5	73.3	54.7	59.2
1	0	0	1250	0	70	75.8	76.7	73.6	74.03
1	0	1	1260	0	70	78.8	73.3	73.6	73.93
1	0	1	1140	0	70	97	93.3	88.7	87.25
1	0	1	1350	0	90	75.8	76.7	66	77.13

1	0	1	1190	1	93.3	100	100	86.8	95.03
1	2	1	1200	1	90	75.8	96.7	77.4	84.98
1	4	0	1320	1	93.3	90.9	103.3	86.8	93.58
1	5	0	1060	0	90	84.8	76.7	79.2	82.68
1	0	1	1150	0	63.3	48.5	60	62.3	58.53
1	0	0	1370	0	63.3	36.4	73.3	62.3	58.83
1	0	1	1270	0	73.3	54.5	70	75.5	68.33
1	4	1	1040	0	40	54.5	60	56.6	52.78
1	0	1	1270	0	66.7	66.7	76.7	60.4	67.63
1	2	1	1010	1	69.7	78.8	63.3	87.5	74.83
1	1	1	970	0	81.8	87.9	83.3	80	83.25
1	0	0	1110	0	54.5	48.5	36.7	62.5	50.55
1	0	1	1030	0	60.6	72.7	70	90	73.33
1	0	1	1210	0	75.8	75.8	66.7	60	69.58
1	0	1	950	0	66.7	72.7	60	92.5	72.98
1	0	1	980	0	81.8	84.8	63.3	77.5	76.85
1	0	1	1130	0	90.9	81.8	70	80	80.68
1	2	1	1090	0	66.7	63.6	53.3	65	62.15
1	5	1	1190	0	63.6	81.8	70	87.5	75.73
1	2	1	980	1	75.8	81.8	76.7	85	79.83
1	0	1	1210	0	93.9	78.8	73.3	95	85.25
1	0	1	1000	1	69.7	57.6	46.7	52.5	56.63
1	2	1	1090	0	63.6	78.8	30	55	56.85
1	0	0	1240	1	72.7	81.8	63.3	82.5	75.08
1	3	1	1050	0	51.5	63.6	56.7	52.5	56.08
1	0	0	1110	0	66.7	54.5	56.7	50	56.98
1	0	0	1280	0	93.9	75.8	60	72.5	75.55
1	1	1	1120	0	66.7	69.7	50	70	64.1
1	2	0	1040	0	54.5	84.8	76.7	87.5	75.88
1	0	0	1330	0	81.8	75.8	73.3	80	77.73
1	0	0	1300	1	75.8	78.8	76.7	87.5	79.7
1	1	0	870	1	69.7	63.6	46.7	72.5	63.13
1	3	1	1160	0	63.6	72.7	46.7	60	60.75
1	0	1	1180	0	57.6	54.5	50	57.5	54.9
1	1	1	1190	0	66.7	75.8	73.3	62.5	69.58
1	0	0	1020	0	84.8	84.8	80	92.5	85.53
1	2	1	840	1	63.6	69.7	66.7	72.5	68.13
1	0	1	1160	0	63.6	87.9	76.7	92.5	80.18
1	0	1	1210	0	84.8	69.7	53.3	85	73.2
1	1	1	960	0	63.6	84.8	83.3	92.5	81.05
1	1	0	1260	0	72.7	81.8	83.3	80	79.45
1	1	0	1390	0	69.7	84.8	80	90	81.13
1	5	1	1120	1	87.9	93.9	83.3	100	91.28

1	0	1	920	0	51.5	54.5	53.3	50	52.33
1	2	0	1070	0	75.8	81.8	63.3	70	72.73
1	0	1	1150	0	84.8	75.8	63.3	87.5	77.85
1	2	1	1010	0	60.6	72.7	53.3	75	65.4
1	5	1	1290	0	75.8	81.8	63.3	90	77.73
1	0	0	1140	0	81.8	90.9	80	95	86.93
1	2	0	1120	0	60.6	63.6	43.3	92.5	65
1	2	1	1070	1	60.6	69.7	63.3	80	68.4
1	0	0	1250	0	72.7	75.8	56.7	72.5	69.43
1	0	1	970	1	75.8	84.8	83.3	85	82.23
1	0	1	1400	1	90.9	84.8	70	95	85.18
1	0	1	1160	0	63.6	63.6	46.7	50	55.98
1	0	0	1150	0	69.7	93.9	66.7	92.5	80.7
1	3	0	1440	1	75.8	66.7	76.7	82.5	75.43
1	3	1	1160	0	60.6	81.8	73.3	87.5	75.8
1	0	1	1230	0	54.5	63.6	86.7	77.5	70.58
1	1	1	1130	0	75.8	66.7	66.7	90	74.8
1	2	1	990	1	60.6	84.8	66.7	57.5	67.4
1	0	0	1250	0	72.7	81.8	60	62.5	69.25
1	0	1	1290	0	72.7	81.8	70	97.5	80.5
1	0	1	1340	0	78.8	97	63.3	95	83.53
1	1	0	950	0	60.6	54.5	40	55	52.53
1	0	1	1090	0	63.6	72.7	66.7	70	68.25
1	2	1	1030	0	48.5	48.5	30	95	55.5
1	5	1	1410	1	78.8	90.9	76.7	102.5	87.23
1	4	1	870	0	60.6	75.8	56.7	70	65.78
1	0	1	1080	0	75.8	78.8	73.3	80	76.98
1	0	1	1190	0	66.7	57.6	53.3	72.5	62.53
1	5	0	1270	0	78.8	78.8	63.3	87.5	77.1
1	0	1	1140	0	63.6	72.7	66.7	65	67
1	2	1	1010	0	57.6	78.8	36.7	72.5	61.4
1	0	1	1120	0	69.7	66.7	66.7	77.5	70.15
1	0	0	1230	0	84.8	81.8	80	92.5	84.78
1	0	1	1180	0	69.7	87.9	80	77.5	78.78
1	1	0	1220	0	66.7	54.5	86.7	80	71.98
1	0	1	1160	0	63.6	54.5	56.7	67.5	60.58
1	1	1	1050	1	54.5	48.5	43.3	47.5	48.45
1	0	0	1150	0	87.9	84.8	80	90	85.68
1	2	1	1140	1	78.8	78.8	60	87.5	76.28
1	5	1	1110	0	63.6	72.7	66.7	92.5	73.88
1	0	1	1070	0	81.8	84.8	86.7	90	85.83
1	2	0	1210	0	72.7	84.8	70	62.5	72.5
1	0	0	1100	0	57.6	72.7	60	52.5	60.7

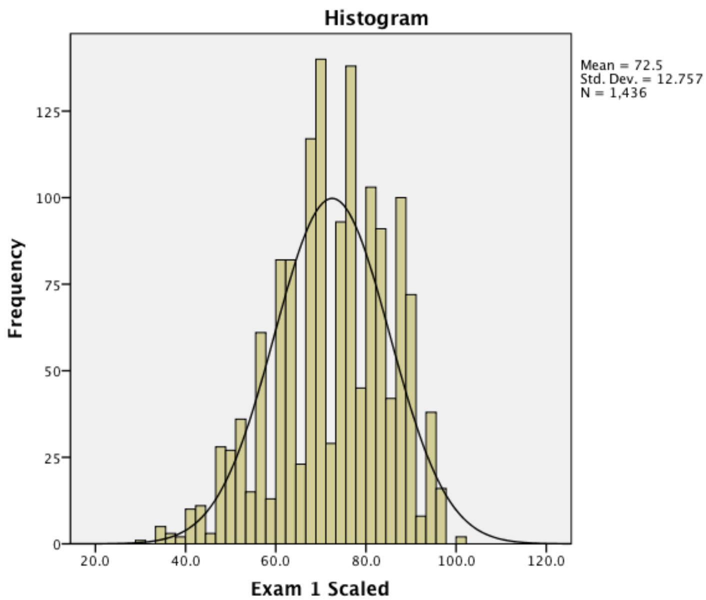
1	0	1	1110	0	72.7	84.8	73.3	70	75.2
1	0	0	1250	0	63.6	57.6	66.7	65	63.23
1	2	1	970	0	66.7	66.7	50	72.5	63.98
1	0	1	1180	0	81.8	90.9	66.7	92.5	82.98
1	1	0	890	0	54.5	39.4	26.7	37.5	39.53
1	0	1	1040	1	63.6	81.8	66.7	95	76.78
1	0	1	1050	0	78.8	84.8	70	82.5	79.03
1	0	0	1310	0	66.7	72.7	70	77.5	71.73
1	0	1	1020	0	57.6	90.9	66.7	85	75.05
1	2	1	1040	0	81.8	87.9	73.3	97.5	85.13
1	3	1	1170	0	66.7	75.8	73.3	62.5	69.58
1	0	1	1290	0	69.7	78.8	60	80	72.13
1	5	0	1190	1	84.8	81.8	73.3	52.5	73.1
1	0	0	1270	0	72.7	57.6	66.7	65	65.5
1	0	0	1380	0	69.7	72.7	73.3	80	73.93
1	1	1	1090	0	69.7	84.8	76.7	82.5	78.43
1	0	1	1190	0	57.6	69.7	66.7	70	66
1	1	1	1060	1	57.6	69.7	56.7	85	67.25
1	3	0	1130	1	78.8	87.9	73.3	97.5	84.38
1	0	1	1310	0	63.6	93.9	70	80	76.88
1	0	1	1210	0	60.6	75.8	73.3	87.5	74.3
1	1	1	990	0	72.7	75.8	50	75	68.38
1	0	1	1140	1	75.8	69.7	60	75	70.13
1	2	1	1140	1	60.6	84.8	86.7	85	79.28
1	0	0	1230	0	72.7	69.7	70	82.5	73.73
1	5	1	890	0	63.6	66.7	56.7	75	65.5
1	0	1	910	0	63.6	87.9	46.7	65	65.8
1	5	1	1120	0	48.5	42.4	43.3	67.5	50.43
1	3	1	1100	0	48.5	60.6	46.7	65	55.2
1	0	1	1030	0	84.8	84.8	70	75	78.65
1	0	1	1120	0	72.7	87.9	73.3	90	80.98
1	0	0	1100	1	60.6	66.7	36.7	57.5	55.38
1	3	1	950	0	45.5	51.5	66.7	70	58.43
1	0	1	1230	0	66.7	72.7	66.7	72.5	69.65
1	0	1	1060	0	84.8	72.7	63.3	57.5	69.58
1	0	1	1080	0	93.9	81.8	53.3	50	69.75
1	0	1	1210	0	81.8	93.9	63.3	85	81
1	1	0	1230	0	60.6	87.9	50	65	65.88
1	4	1	970	1	81.8	78.8	56.7	95	78.08
1	0	1	1080	0	75.8	66.7	66.7	85	73.55
1	0	0	1150	0	69.7	75.8	66.7	80	73.05
1	1	1	1250	0	63.6	69.7	73.3	75	70.4
1	0	1	1240	0	84.8	90.9	66.7	95	84.35

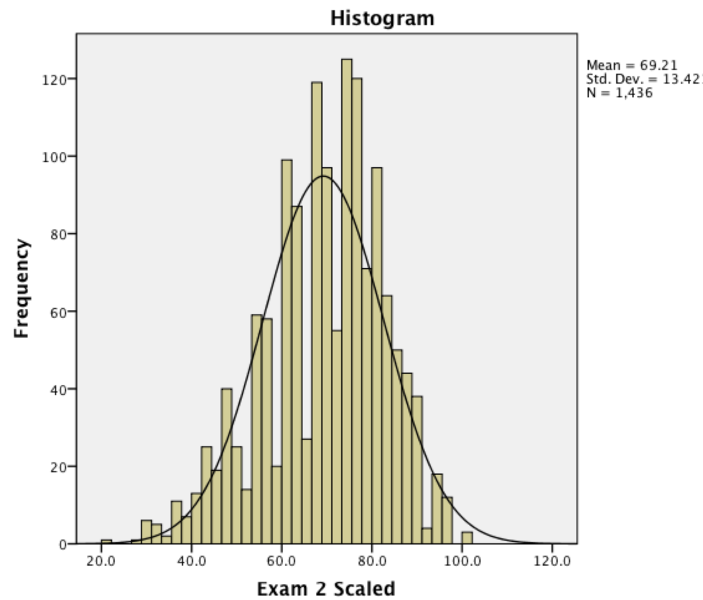
1	0	0	1430	0	72.7	81.8	90	70	78.63
1	3	1	1170	0	63.6	78.8	46.7	77.5	66.65
1	0	1	1200	0	63.6	87.9	70	95	79.13
1	0	1	1150	1	81.8	90.9	73.3	100	86.5
1	1	0	980	0	57.6	69.7	60	87.5	68.7
1	1	1	930	0	57.6	87.9	83.3	80	77.2
1	0	1	1240	0	66.7	69.7	66.7	75	69.53
1	0	1	1250	0	78.8	78.8	53.3	75	71.48
1	3	1	1150	1	66.7	84.8	73.3	87.5	78.08
1	3	1	1200	0	78.8	72.7	80	95	81.63
1	0	1	1210	1	75.8	93.9	90	87.5	86.8
1	0	1	970	0	66.7	60.6	60	57.5	61.2
1	0	1	1250	1	78.8	84.8	80	85	82.15
1	0	1	1170	0	72.7	78.8	80	77.5	77.25
1	0	1	1210	1	87.9	84.8	83.3	97.5	88.38
1	3	0	1010	1	66.7	78.8	53.3	72.5	67.83
1	1	1	1000	0	54.5	57.6	50	70	58.03
1	5	1	920	0	60.6	48.5	43.3	37.5	47.48
1	0	1	1060	0	69.7	81.8	66.7	72.5	72.68
1	0	1	1110	0	69.7	72.7	53.3	55	62.68
1	0	1	1080	0	57.6	63.6	46.7	77.5	61.35
1	0	0	1050	0	57.6	45.5	63.3	62.5	57.23
1	0	1	1330	0	63.6	57.6	60	50	57.8
1	0	1	1040	0	63.6	81.8	63.3	70	69.68
1	1	1	1230	1	81.8	84.8	76.7	97.5	85.2
1	2	0	1250	1	66.7	78.8	70	70	71.38
1	2	1	1150	1	87.9	90.9	86.7	97.5	90.75
1	2	0	930	1	69.7	66.7	46.7	55	59.53
1	1	1	1050	1	87.9	87.9	93.3	95	91.03
1	1	1	930	1	75.8	72.7	80	82.5	77.75
1	2	1	1060	0	78.8	87.9	60	95	80.43
1	1	1	1230	0	78.8	66.7	90	95	82.63
1	3	1	1300	0	57.6	72.7	40	55	56.33
1	0	0	1130	0	66.7	69.7	63.3	95	73.68
1	0	0	1250	0	78.8	78.8	43.3	55	63.98
1	0	0	1060	0	45.5	48.5	40	40	43.5
1	0	0	1240	1	72.7	84.8	53.3	75	71.45
1	0	0	1310	1	69.7	75.8	76.7	85	76.8
1	0	1	1030	0	54.5	78.8	76.7	80	72.5
1	2	1	910	0	57.6	51.5	40	50	49.78
1	0	0	1120	1	66.7	87.9	83.3	87.5	81.35
1	0	0	1000	1	75.8	84.8	70	87.5	79.53
1	5	0	1270	0	78.8	57.6	56.7	65	64.53

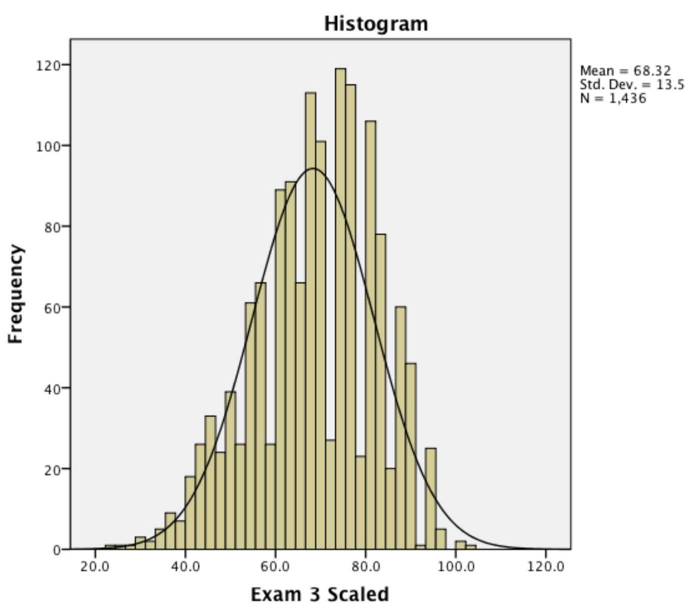
1	2	0	1230	0	66.7	69.7	40	65	60.35
1	1	1	1040	0	66.7	63.6	76.7	75	70.5
1	0	1	1200	1	78.8	69.7	66.7	90	76.3

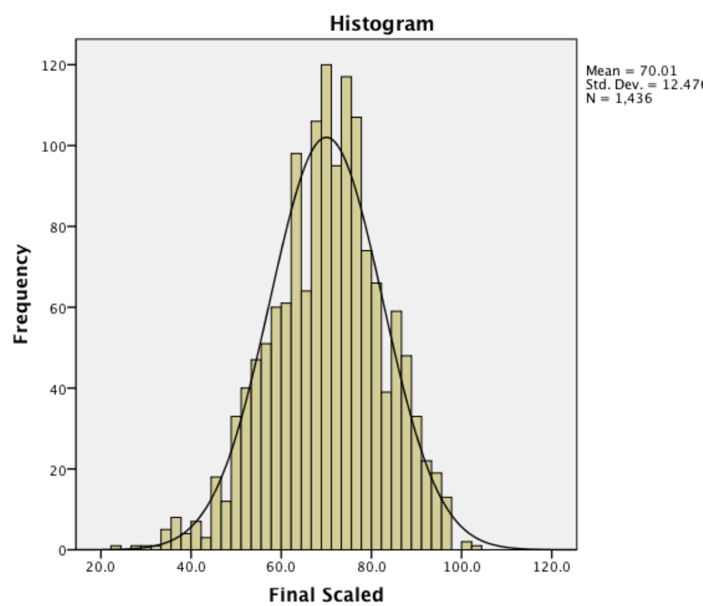
Appendix D

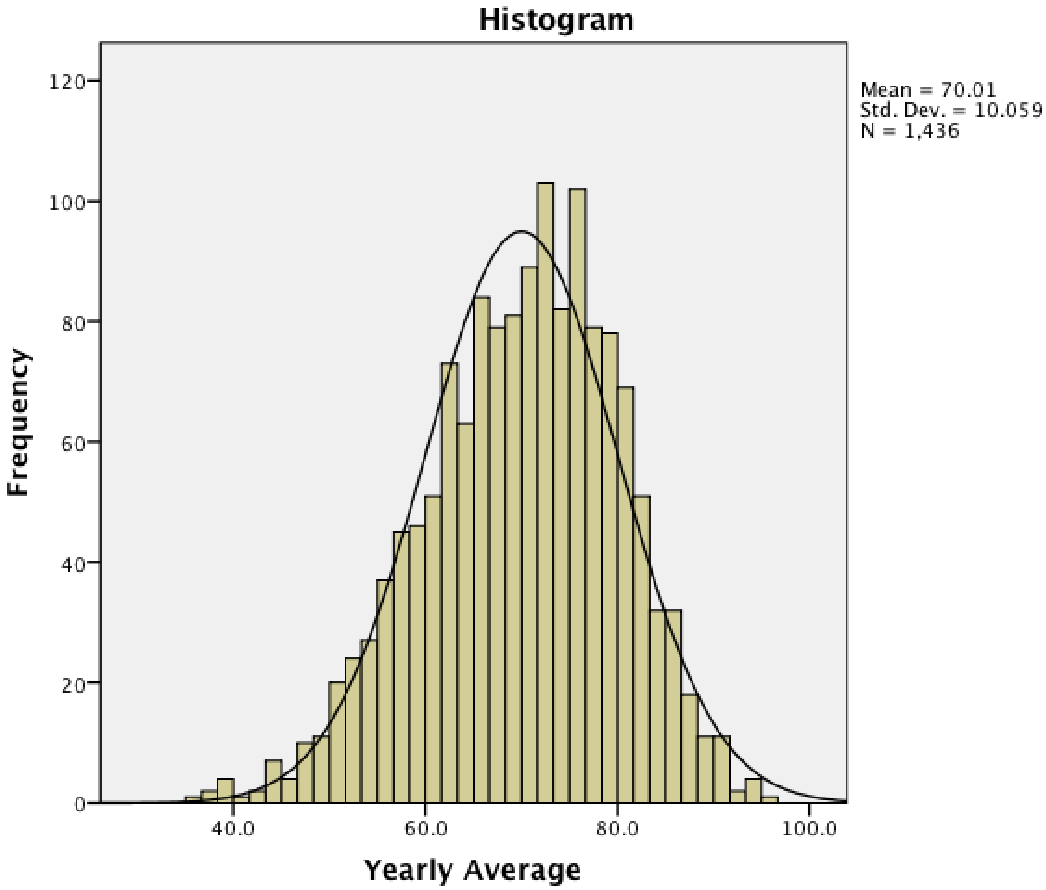
Histograms for Continuous Dependent Variables



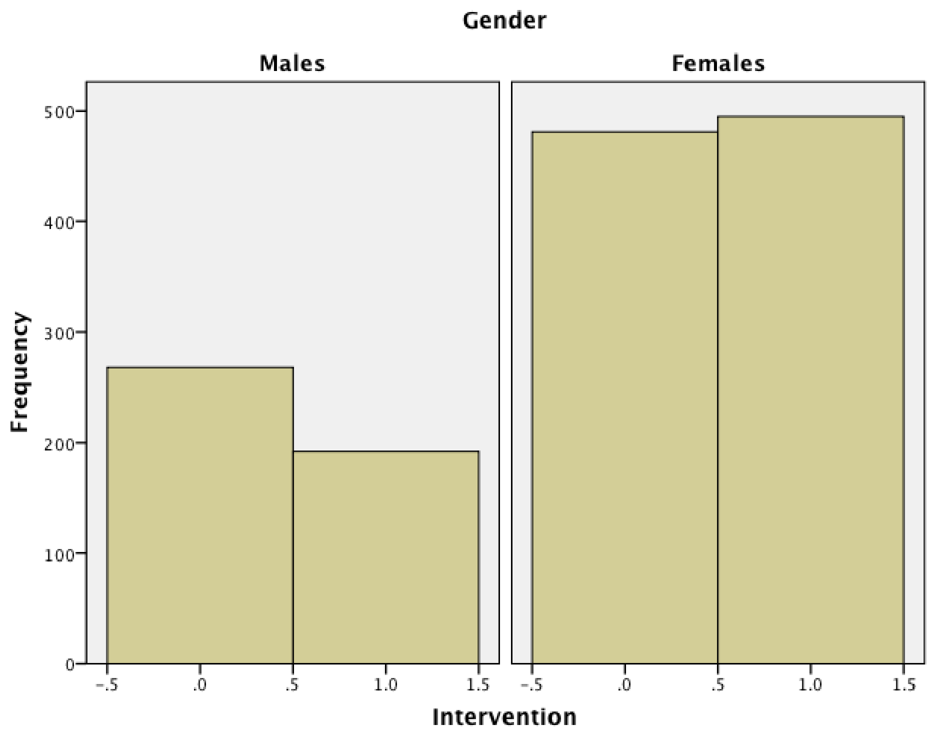


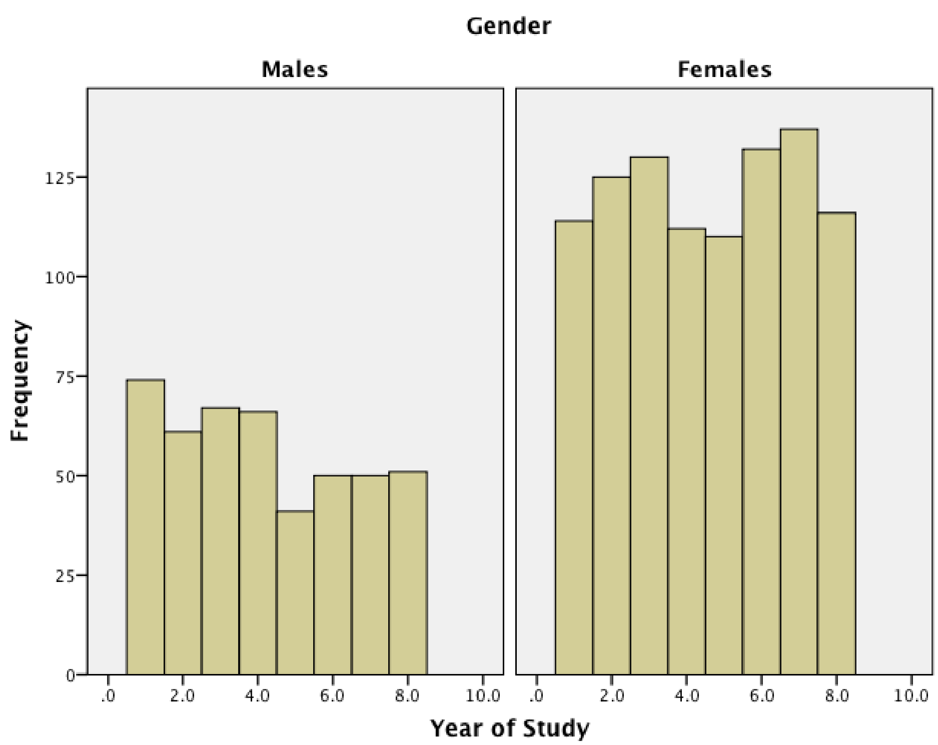


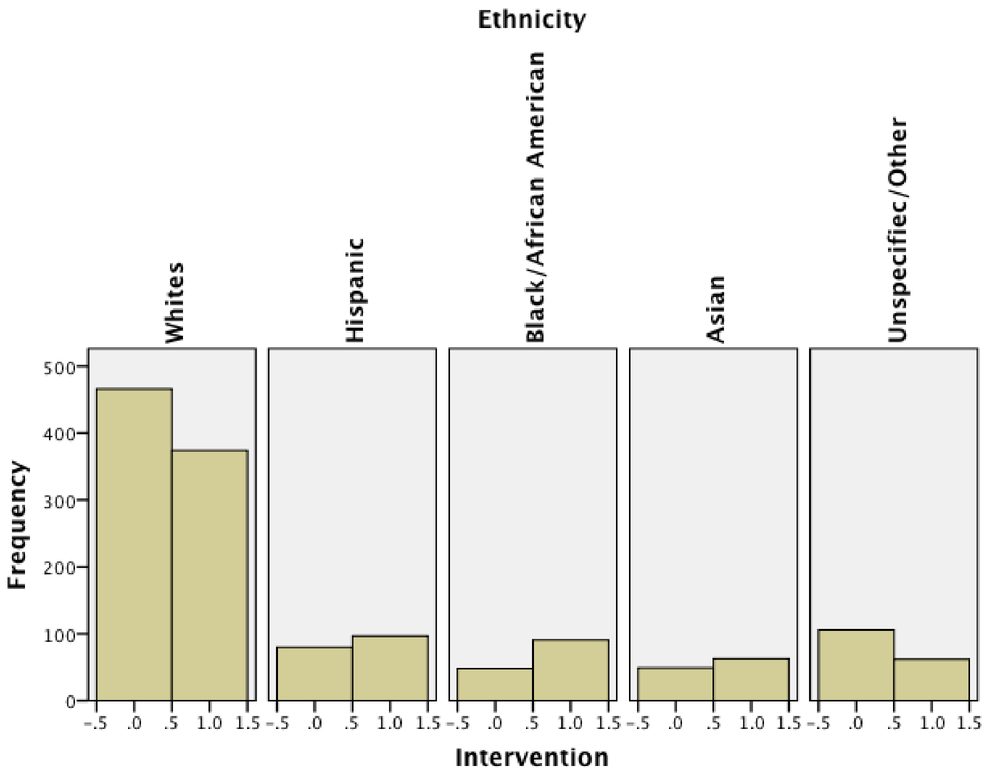


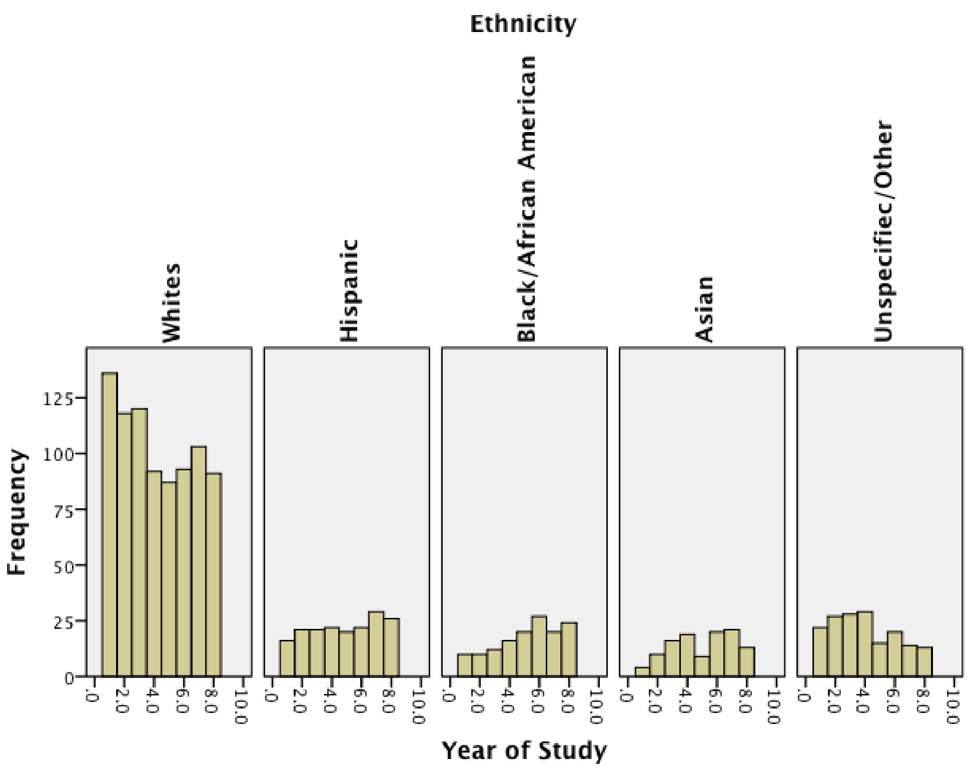

Histogram
Mean = 70.01
Std. Dev. = 10.059
N = 1,436
Frequency
0
20
40
60
80
100
120
40.0
60.0
80.0
100.0
Yearly Average

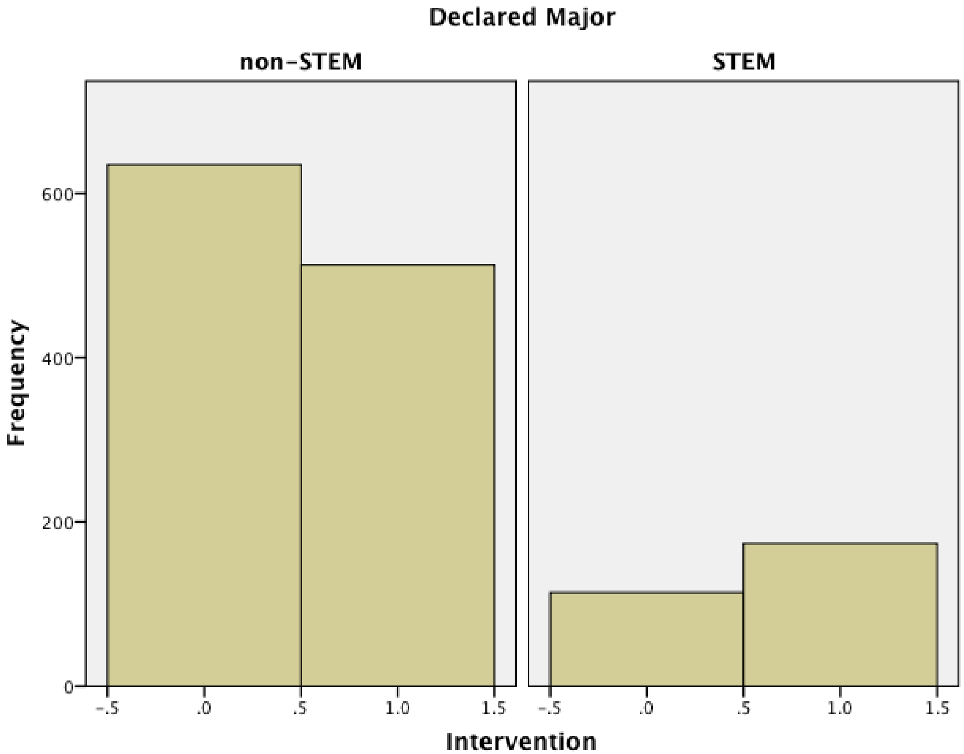
Bar Charts for Nominal Independent Variables (Covariables)

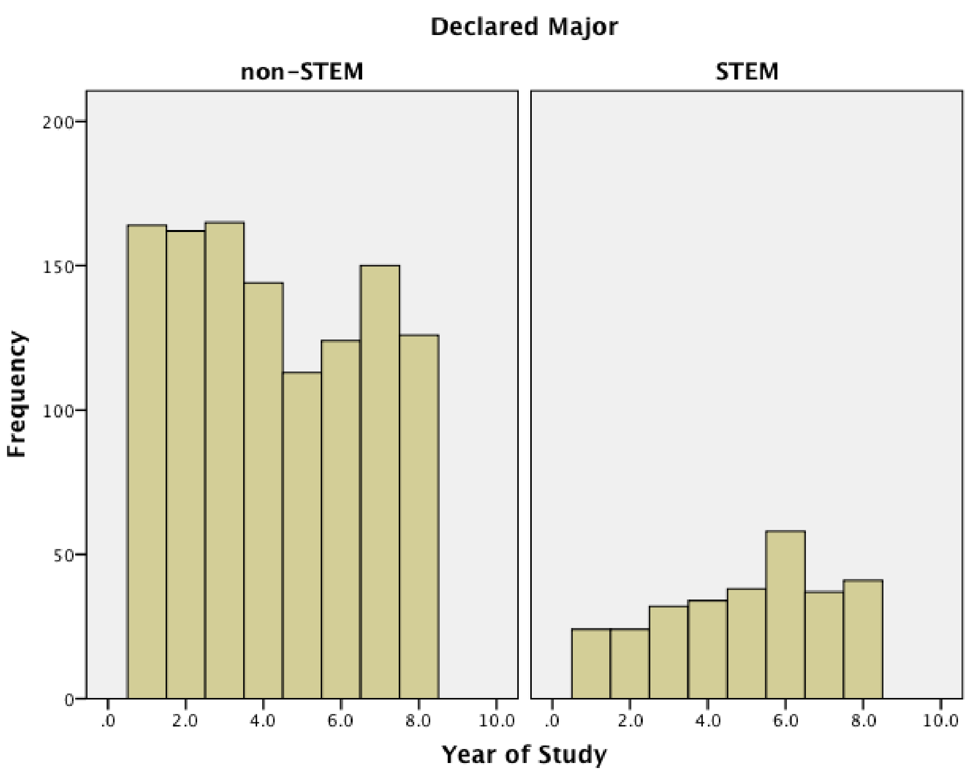




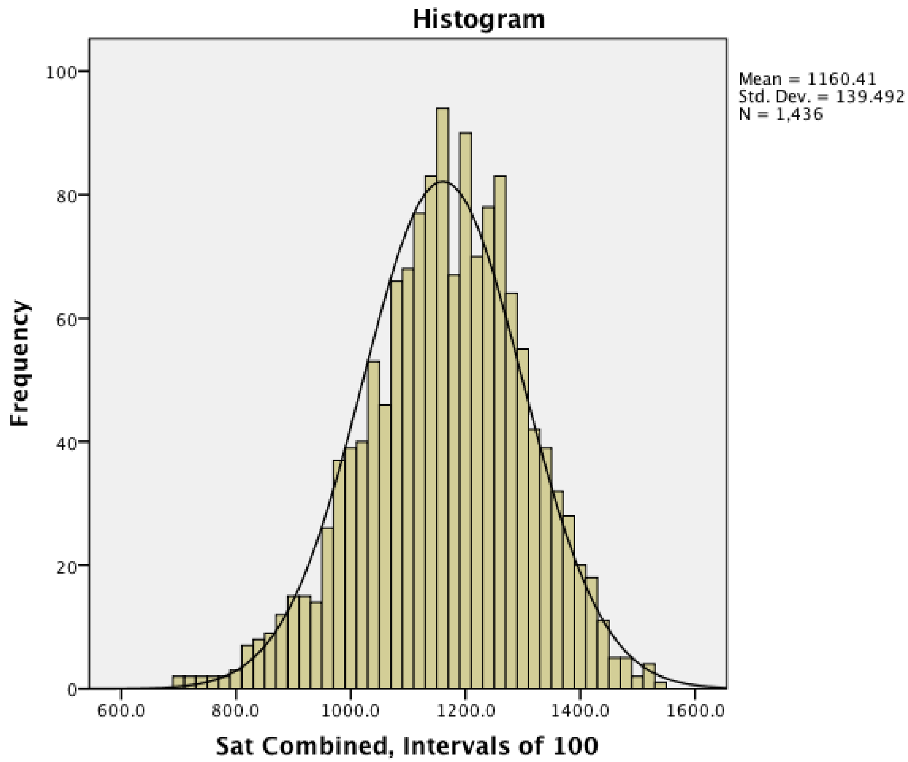

Ethnicity
Whites
Hispanic
Black/African American
Asian
Unspecifiec/Other
Frequency
500
400
300
200
100
0
-.5 .0 .5 1.0 1.5
Intervention

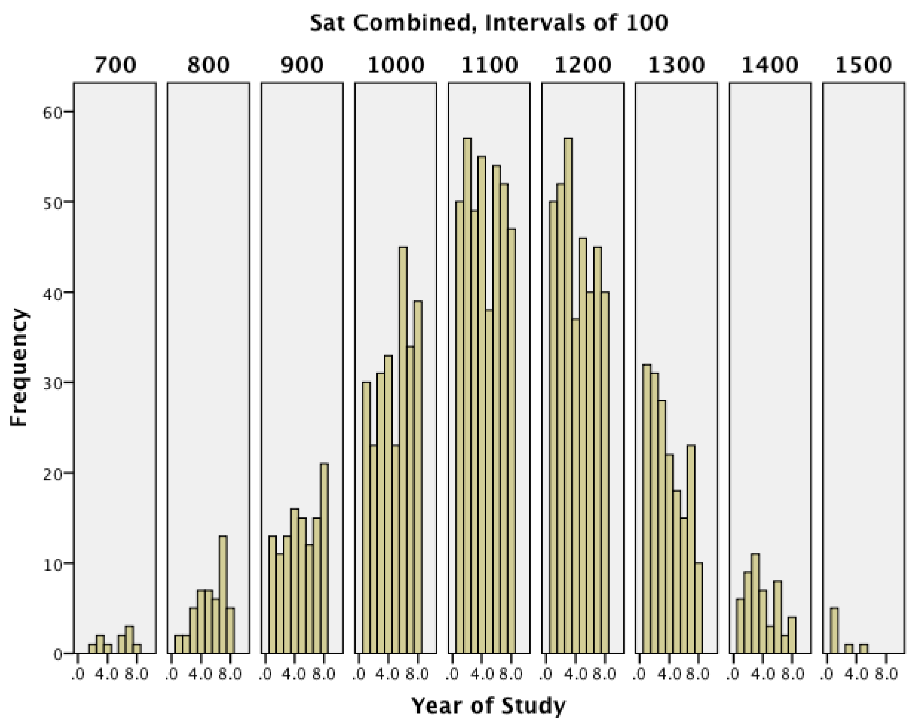

Ethnicity
Whites
Hispanic
Black/African American
Asian
Unspecifiec/Other
Frequency
125
100
75
50
25
0
.0 2.0 4.0 6.0 8.0 10.0
Year of Study


Declared Major
non-STEM
STEM
Frequency
0
200
400
600
-.5
.0
.5
1.0
1.5
Intervention


Declared Major
non-STEM
STEM
Frequency
0
50
100
150
200
.0
2.0
4.0
6.0
8.0
10.0
Year of Study

Histograms for Continuous Independent Variables





Appendix E

Comparisons between a continuous variable and a categorical variable

Note. Inclusion of the independent variable in multivariate work occurs at an alpha of 0.15.

Levene's Test of Equality of Error Variances[a]

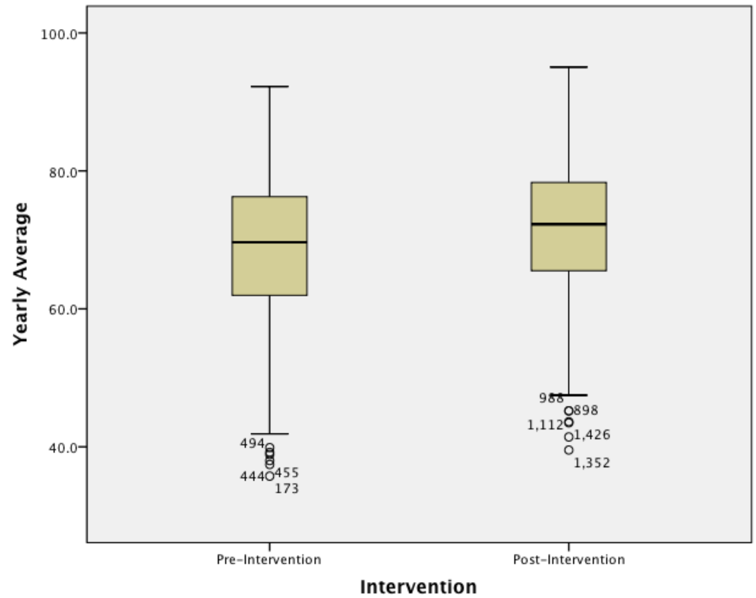
Dependent Variable: Student class average

F	df1	df2	Sig.
4.880	1	1434	.027

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Intervention

*Equal variance assumption is valid, $F(1, 1434) = 4.88$, $p = 0.027$



Levene's Test of Equality of Error Variances[a]

Dependent Variable: Student class average

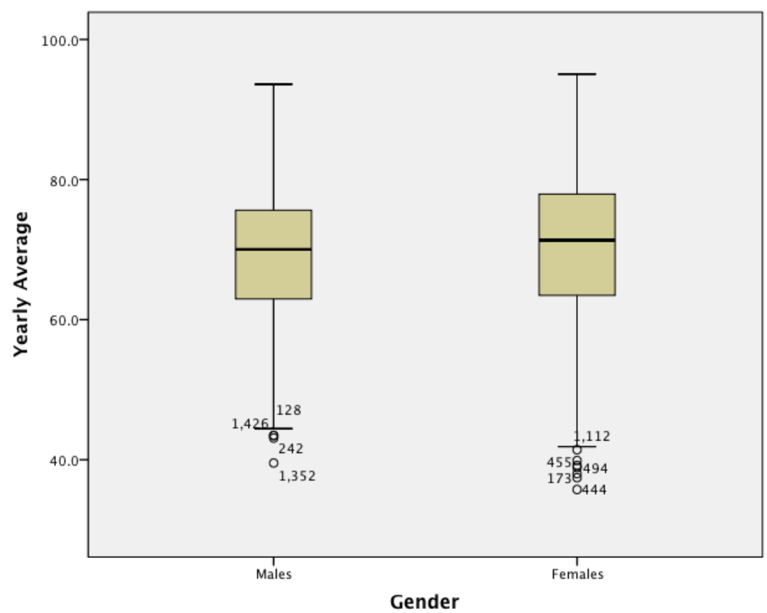
F	df1	df2	Sig.
2.642	1	1434	.104

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gender

* Equal variance assumption is valid, $F(1, 1434) = 2.64$, $p = 0.104$

*



Levene's Test of Equality of Error Variances[a]

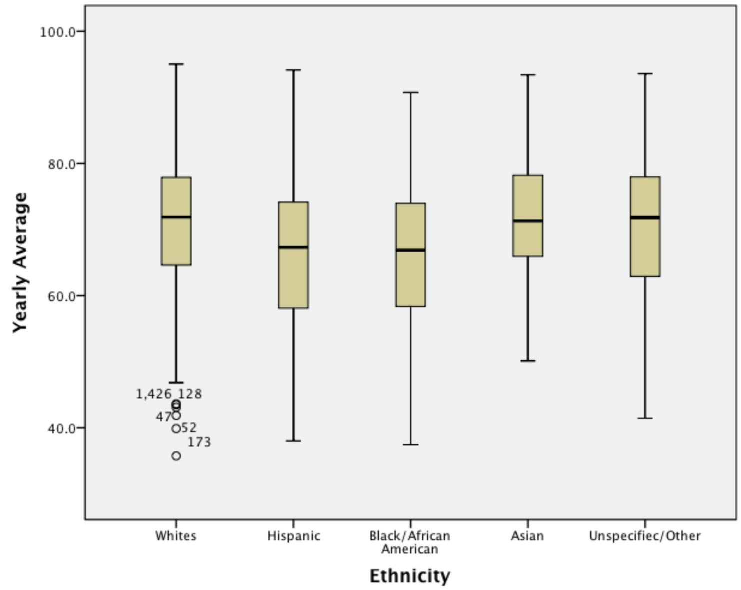
Dependent Variable: Student class average

F	df1	df2	Sig.
2.836	4	1431	.023

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Ethnicity

*Equal variance assumption is valid, F(1, 1431) = 2.84, *p* = 0.023



Levene's Test of Equality of Error Variances[a]

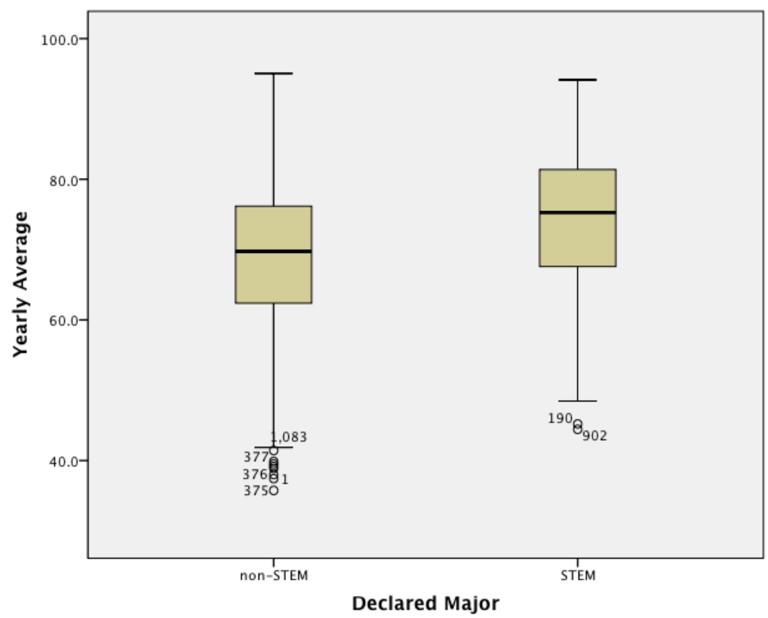
Dependent Variable: Student class average

F	df1	df2	Sig.
.002	1	1434	.963

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + AcadPlan1

*Equal variance assumption is not valid, F(1, 1434) = 0.02, *p* = 0.963



Summary ANOVA bivariate screening

	Df	F	***p***	R^2
Yearly Avg + Intervention	(1,1434)	25.46	.000	.017
Yearly Avg + Gender	(1,1434)	4.90	.027	.003
Yearly Avg + Ethnicity	(4,1431)	13.56	.000	.037
Yearly Avg + Declared Major	(1,1434)	60.86	.000	.041
Yearly Avg + SAT Combined	(1,1434)	248.35	.000	.148

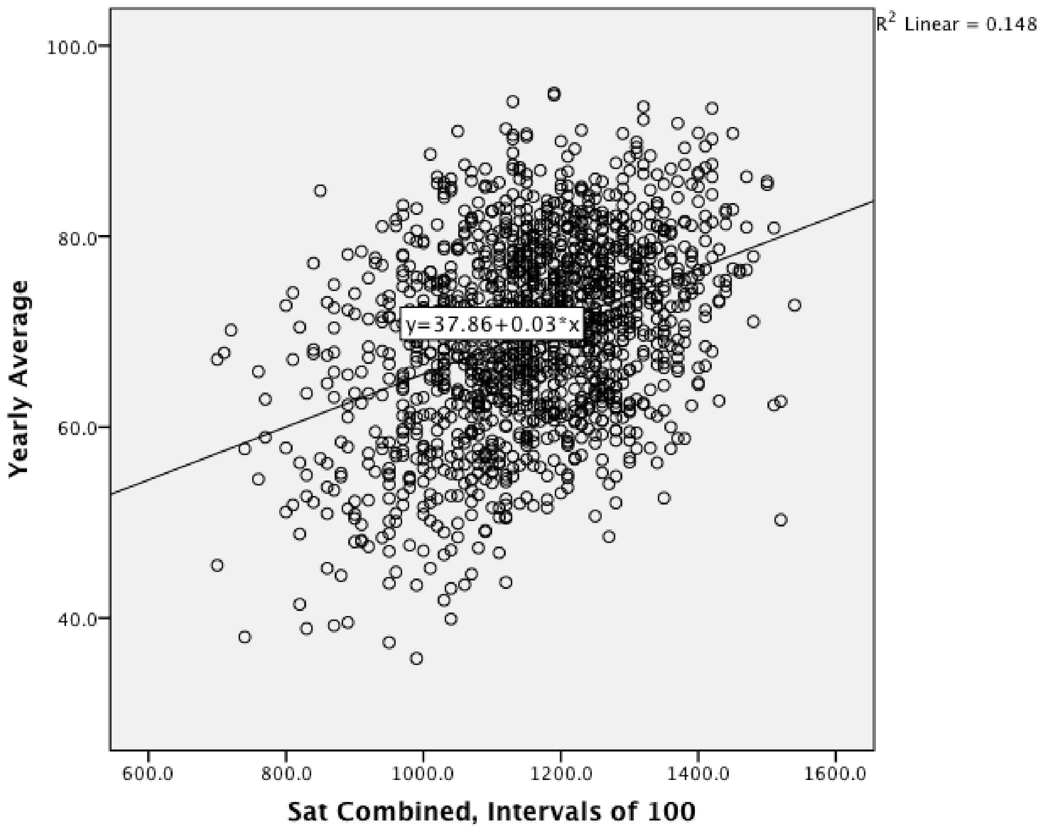
Comparison between two continuous variables

Correlations

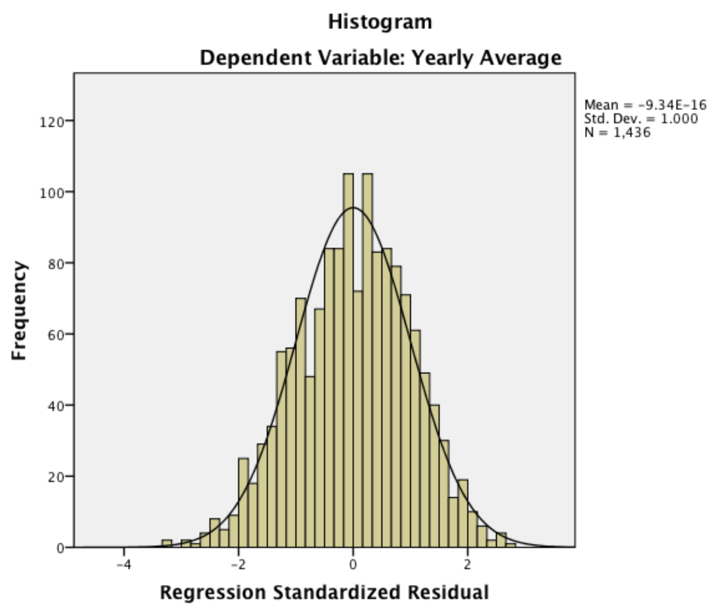
		Sat Combined, Intervals of 100	Student class average
Sat Combined, Intervals of 100	Pearson Correlation	1	.384**
	Sig. (2-tailed)		.000
	N	1436	1436
Student class average	Pearson Correlation	.384**	1
	Sig. (2-tailed)	.000	
	N	1436	1436

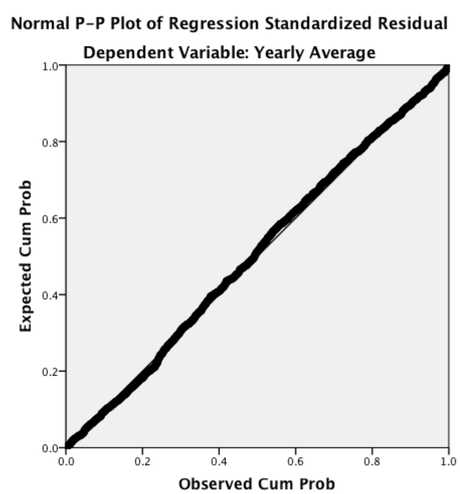
**. Correlation is significant at the 0.01 level (2-tailed).

*Statistically significant, marginally strong positive correlation between SAT scores and the student class average

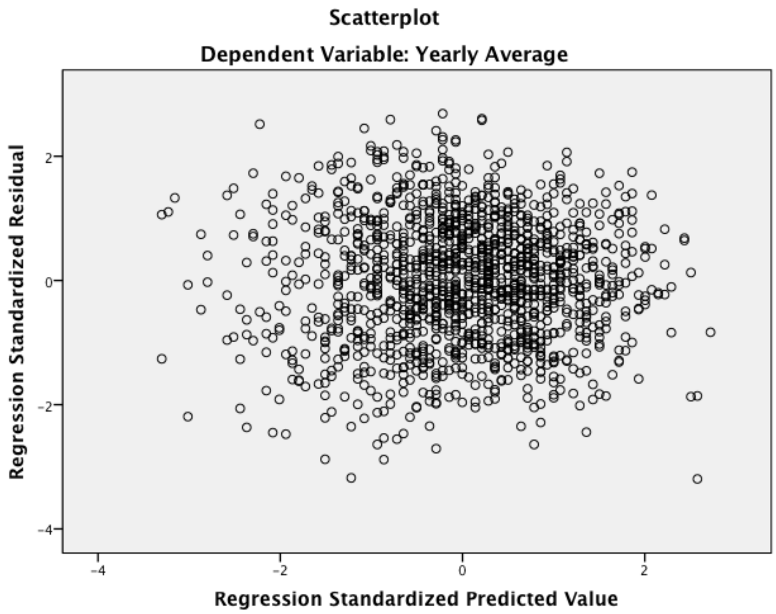


* Every increase in 1 unit raises the expected Student class average 0.028 (or 2.8 points for every 100 interval) and this relationship explains about 17.9% of observed variability.





*A better way to assess normality, and it, too, says that the normality assumption is met



* the ‘cloud’ is about the same width across all levels of predicted value, so it can be concluded that the equal variance assumption is met. The assumption of linearity was confirmed by the significance of the linear regression and the Pearson correlation.

Appendix F -

Descriptive Statistics

Dependent Variable: Student class average

Declared Major	Intervention	Ethnicity	Gender	Mean	Std. Deviation	N
non-STEM	Pre-Intervention	Whites	Males	68.711	9.0851	164
			Females	69.260	10.1282	236
			Total	69.034	9.7061	400
		Hispanic	Males	60.179	10.1604	15
			Females	62.605	9.4860	50
			Total	62.045	9.6196	65
		Black/African American	Males	65.033	9.1795	15
			Females	60.000	13.2941	26
			Total	61.841	12.0820	41
		Asian	Males	72.606	7.4216	7
			Females	71.135	8.4773	31
			Total	71.406	8.2179	38
		Unspecified/Other	Males	70.349	9.5733	33
			Females	68.160	9.5288	58
			Total	68.954	9.5504	91
		Total	Males	68.275	9.4454	234
			Females	67.815	10.4942	401
			Total	67.985	10.1153	635
	Post-Intervention	Whites	Males	70.215	8.3115	94
			Females	72.607	8.6206	198
			Total	71.837	8.5814	292
		Hispanic	Males	70.011	9.8872	19
			Females	68.201	9.8965	50
			Total	68.700	9.8547	69
		Black/African American	Males	60.943	9.9628	11
			Females	66.673	9.7999	52
			Total	65.673	9.9908	63
		Asian	Males	67.461	5.7537	7
			Females	69.388	9.3589	40
			Total	69.101	8.8915	47
		Unspecified/Other	Males	68.424	9.0808	9
			Females	70.141	11.0211	33
			Total	69.773	10.5547	42
		Total	Males	69.206	8.8638	140
			Females	70.626	9.5027	373
			Total	70.238	9.3456	513
	Total	Whites	Males	69.259	8.8246	258
			Females	70.787	9.6057	434

			Total	70.217	9.3450	692
		Hispanic	Males	65.673	11.0306	34
			Females	65.403	10.0460	100
			Total	65.472	10.2629	134
		Black/African American	Males	63.303	9.5465	26
			Females	64.449	11.4462	78
			Total	64.162	10.9687	104
		Asian	Males	70.034	6.9159	14
			Females	70.151	8.9643	71
			Total	70.131	8.6238	85
		Unspecified/Other	Males	69.936	9.3946	42
			Females	68.878	10.0802	91
			Total	69.212	9.8456	133
		Total	Males	68.624	9.2310	374
			Females	69.170	10.1202	774
			Total	68.992	9.8387	1148
STEM	Pre-Intervention	Whites	Males	72.974	10.4289	17
			Females	74.221	9.2093	49
			Total	73.900	9.4712	66
		Hispanic	Males	64.341	15.9058	4
			Females	74.576	11.0372	11
			Total	71.846	12.7741	15
		Black/African American	Males	67.445	.	1
			Females	70.101	10.7122	6
			Total	69.722	9.8302	7
		Asian	Males	77.097	10.5165	6
			Females	75.438	6.9885	5
			Total	76.343	8.6940	11
		Unspecified/Other	Males	66.528	11.0914	6
			Females	70.106	9.2921	9
			Total	68.675	9.8268	15
		Total	Males	71.386	11.3639	34
			Females	73.574	9.3987	80
			Total	72.921	10.0240	114
	Post-Intervention	Whites	Males	73.628	9.4066	25
			Females	77.585	8.5409	57
			Total	76.378	8.9448	82
		Hispanic	Males	63.819	5.9495	8
			Females	71.303	12.9138	20
			Total	69.165	11.7637	28
		Black/African American	Males	66.417	4.7672	7
			Females	75.193	7.0649	21
			Total	72.999	7.5497	28
		Asian	Males	73.667	11.9873	6
			Females	75.489	10.2941	10
			Total	74.806	10.5976	16

		Unspecified/Other	Males	76.642	15.6492	6
			Females	79.683	5.9594	14
			Total	78.771	9.5283	20
		Total	Males	71.500	10.2933	52
			Females	76.212	9.2942	122
			Total	74.804	9.8148	174
	Total	Whites	Males	73.363	9.7131	42
			Females	76.030	8.9731	106
			Total	75.273	9.2348	148
		Hispanic	Males	63.993	9.5703	12
			Females	72.465	12.1966	31
			Total	70.100	12.0427	43
		Black/African American	Males	66.546	4.4285	8
			Females	74.062	8.0694	27
			Total	72.344	8.0053	35
		Asian	Males	75.382	10.8993	12
			Females	75.472	9.0596	15
			Total	75.432	9.7189	27
		Unspecified/Other	Males	71.585	13.9690	12
			Females	75.935	8.6731	23
			Total	74.444	10.7793	35
		Total	Males	71.455	10.6635	86
			Females	75.167	9.4018	202
			Total	74.059	9.9237	288
Total	Pre-Intervention	Whites	Males	69.111	9.2719	181
			Females	70.112	10.1357	285
			Total	69.724	9.8112	466
		Hispanic	Males	61.055	11.2026	19
			Females	64.763	10.7389	61
			Total	63.883	10.8952	80
		Black/African American	Males	65.183	8.8887	16
			Females	61.894	13.3072	32
			Total	62.990	12.0196	48
		Asian	Males	74.679	8.8911	13
			Females	71.732	8.3341	36
			Total	72.514	8.4933	49
		Unspecified/Other	Males	69.761	9.7629	39
			Females	68.421	9.4514	67
			Total	68.914	9.5428	106
		Total	Males	68.670	9.7412	268
			Females	68.773	10.5319	481
			Total	68.736	10.2495	749
	Post-Intervention	Whites	Males	70.932	8.6250	119
			Females	73.720	8.8339	255
			Total	72.833	8.8525	374

	Hispanic	Males	68.176	9.2471	27
		Females	69.088	10.8381	70
		Total	68.834	10.3805	97
	Black/African American	Males	63.072	8.5992	18
		Females	69.124	9.8475	73
		Total	67.927	9.8703	91
	Asian	Males	70.325	9.3165	13
		Females	70.608	9.7597	50
		Total	70.550	9.5965	63
	Unspecified/Other	Males	71.711	12.3269	15
		Females	72.983	10.6766	47
		Total	72.675	11.0062	62
	Total	Males	69.827	9.3012	192
		Females	72.003	9.7451	495
		Total	71.395	9.6659	687
Total	Whites	Males	69.833	9.0503	300
		Females	71.816	9.7033	540
		Total	71.108	9.5174	840
	Hispanic	Males	65.235	10.5912	46
		Females	67.074	10.9664	131
		Total	66.596	10.8704	177
	Black/African American	Males	64.066	8.6690	34
		Females	66.921	11.4500	105
		Total	66.222	10.8761	139
	Asian	Males	72.502	9.1943	26
		Females	71.079	9.1554	86
		Total	71.409	9.1428	112
	Unspecified/Other	Males	70.302	10.4525	54
		Females	70.302	10.1816	114
		Total	70.302	10.2381	168
	Total	Males	69.153	9.5668	460
		Females	70.411	10.2632	976
		Total	70.008	10.0592	1436

Appendix G

Tests of Between Subjects Effects; Initial ANCOVA, full factorial, excluding SAT scores

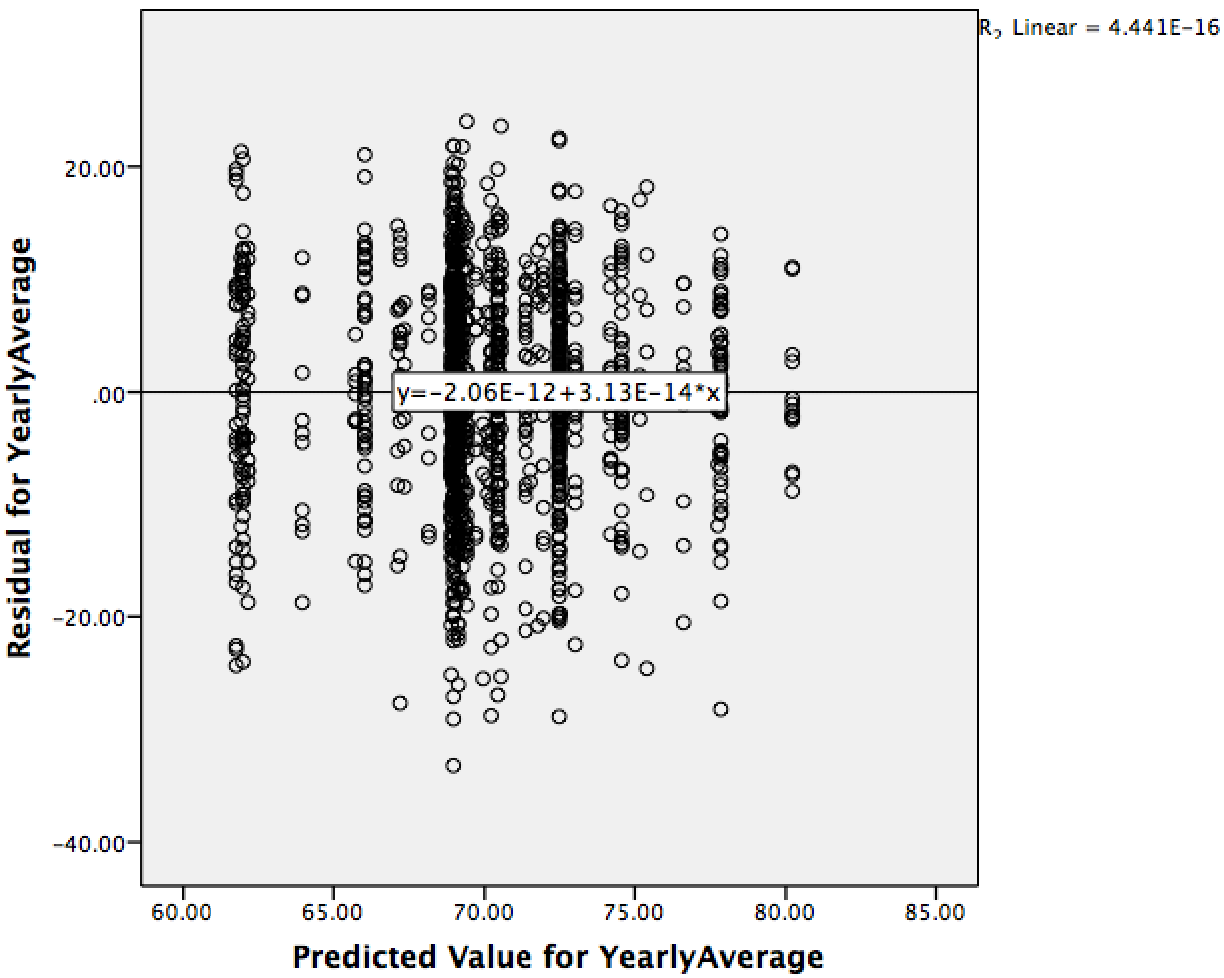
Source	*df*	F	*p*	R^2
Intervention	1	3.638	.057	.003
Ethnicity	4	9.454	.000	.026
Gender	1	5.583	.018	.004
Major	1	24.040	.000	.017
Interv*Ethnic	4	1.546	.186	.004
Interv*Gender	1	1.654	.199	.001
Interv*Major	1	.057	.812	.000
Ethnic*Gender	4	.618	.650	.002
Ethnic*Major	4	.272	.896	.001
Gender*Major	1	3.692	.055	.003
Inter*Ethnic*Gender	4	.817	.514	.002
Inter*Ethnic*Major	4	3.086	.015	.009
Inter*Gender*Major	1	.120	.729	.000
Ethnic*Gender*Major	4	.883	.473	.003
Inter*Ethnic*Gender*Major	3	.137	.969	.000

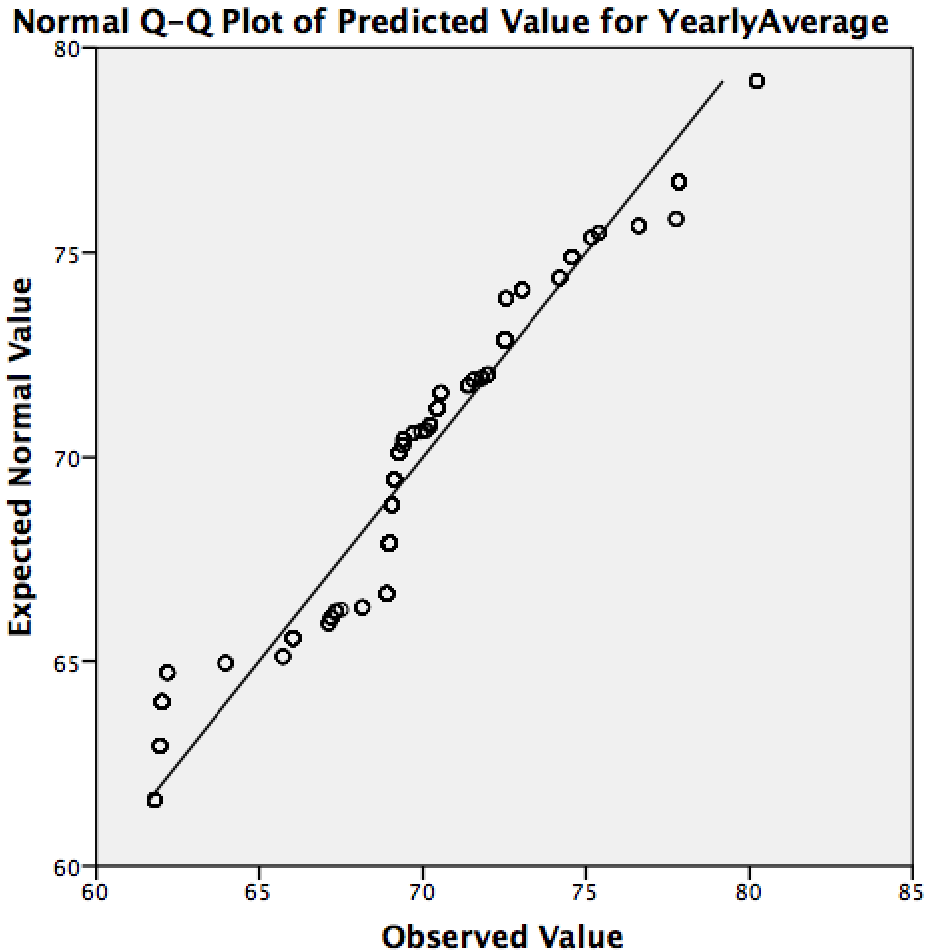
*$R^2 = .134$

Tests of Between Subjects Effects; Final ANCOVA, excluding SAT scores, 7th custom run

Source	*df*	F	*p*	R^2
Intervention	1	4.519	.034	.003
Ethnicity	4	10.605	.000	.029
Gender	1	11.439	.001	.008
Major	1	33.618	.000	.023
Interv*Gender	1	4.029	.045	.003
Gender*Major	1	3.893	.049	.003
Inter*Ethnic*Major	4	1.985	.019	.018

*R^2 = .125




Normal Q-Q Plot of Predicted Value for YearlyAverage
Expected Normal Value
Observed Value
80
75
70
65
60
60
65
70
75
80
85

Summary of ANCOVA, final custom model, descriptors only, excluding SAT, including Parameter Estimates

Source	*df*	t	*p*	Observed[b] power	β
Intervention	1				
Pre		33.99	.001	.90	-10.5
Post		37.21	.000	1.00	0[a]
Ethnicity	4				
Asian		36.21	.317	.17	-2.37
Blk/Afr.Am		33.74	.001	.94	-9.67
Hispanic		35.04	.031	.58	-6.01
White		36.08	.258	.21	-3.60
Unspecified		37.21	.000	1.00	0[a]
Gender	1				
Male		33.52	.000	.96	-4.82
Female		37.21	.000	1.00	0[a]
Major	1				
non-Stem		33.37	.000	.97	-10.00
STEM		37.21	.000	1.00	0[a]

a. mean of 80.22 as standard of 0

b. computed using $\alpha = 1.00$

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Vita

Tyna Lynn Meeks was born in Ilion, NY. After completing her schoolwork at El Capitan High School in Lakeside, California, Tyna entered San Diego State University in San Diego, California in 1991. She received a Bachelor of Science, magna cum laude, in chemistry from San Diego State University in May 1996 and immediately transferred to the State University of New York in Potsdam to begin the Masters of Science Teaching program. Tyna earned her MST degree, summa cum laude, in August 1997 and was employed as a science teacher at Indian River High School in Philadelphia, New York in July 1997. During her second year as an educator, she became an adjunct professor for Syracuse University through Syracuse University Project Advance. In August 2006, she entered the Graduate Program in Chemistry, transferring to the Graduate Program in Science Education in May 2007. Tyna brought the two disciplines together, chemistry and science education, in her research on active learning techniques applied to the college chemistry classroom.