7-2017

Effectiveness of the Flipped Classroom Model in Anatomy and Physiology Laboratory Courses at a Hispanic Serving Institution

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EFFECTIVENESS OF THE FLIPPED CLASSROOM MODEL IN ANATOMY AND PHYSIOLOGY LABORATORY COURSES AT A HISPANIC SERVING INSTITUTION

A Thesis

by

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Submitted to the Graduate College of
The University of Texas Rio Grande Valley
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

July 2017

Major Subject: Biology

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PHYSIOLOGY LABORATORY COURSES AT A

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ABSTRACT

Sanchez, Gerardo, Effectiveness of the Flipped Classroom Model in Anatomy and Physiology Laboratory Courses at a Hispanic Serving Institution. Masters of Science (MS), July, 2017, 86 pp., 8 tables, 33 figures, references, 70 Titles.

A flipped laboratory model involves student preparation on lab material prior to laboratory entry. This allows more laboratory time to be focused on active learning. This study aimed to observe changes in student performance through transition from traditional laboratory format to flipped format. Data showed that for Anatomy and Physiology (I and II) laboratories a more normal grade distribution was observed in flipped labs and lecture grade averages increased. Chi-square and analysis of variance tests showed grade changes to a statistically significant degree ($p<0.05$). Regression analyses gave decreasing numbers after flipped labs were introduced ($r^2 = 0.485$ for A&P I and 0.564 for A&P II). Results indicate improved scores for A&P lecture, decreased outlying scores (>100), and all scores approached a more normal distribution.

DEDICATION

Completion of my graduate studies at The University of Texas Rio Grande Valley is in large part thanks to my loving family, which includes my father, Gerardo Sanchez Sr., my mother, Gloria Sanchez, and my sister, Gabriela Sanchez. Their unwavering support and love enabled me to push my boundaries and strive for excellence in my academic career.

ACKNOWLEDGMENTS

I would like to thank the chair of my dissertation committee, Dr. Kristine Lowe, for her assistance throughout my research. I would also like to thank committee members Dr. Erin Schuenzel and Dr. Christopher Vitek for their guidance on several pedagogical techniques and how to properly test their significance with statistical programs. Dr. Mirayda Torres-Avila was also immensely helpful organizing my research work and providing valuable feedback about the quality of my work. Finally, I would like to express my gratitude to Mrs. Bonnie Gunn. This all began with her research and she allowed me to join in and base my Thesis on the project she began. She also guided me every step of the way, therefore playing a major role in my advancement toward my graduate degree.

I'd also like to acknowledge all my colleagues in the biology graduate program for their assistance in preparing my work, and my fellow Biology/Anatomy and Physiology Teaching Assistants for their encouragement and companionship. They truly made this an unforgettable experience.

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CHAPTER I

INTRODUCTION

In 1956, Bloom and his colleagues created a framework for categorizing educational goals known as the *Taxonomy of Educational Objectives* (Armstrong, 2016). The original taxonomy involved 6 main categories: 1. Knowledge: which involves the recall of information; 2. Comprehension: an understanding of the material being delivered by the instructor; 3. Application: the use of learned material in abstract or concrete situations; 4. Analysis: breaking down learned material to its respective elements or parts; 5. Synthesis: building the broken down elements into its respective whole; and 6. Evaluation: judging the value of the learned material based on its potential applications (Armstrong, 2016). In 2001, the taxonomy was revised by a group of psychologists, curriculum theorists and instructional researchers into the current widely used version (Armstrong, 2016). Categories were renamed with verbs instead of nouns to reflect the various cognitive processes at each level of the taxonomy. The new categories of Bloom's Taxonomy are 1. Remember; 2. Understand; 3. Apply; 4. Analyze; 5. Evaluate; and 6. Create (Armstrong, 2016). Each level retains the basic components. For example, the Understanding level is the ability to explain information, and the Analyze level is the ability to break down information and make connections between the parts. Incorporating Bloom's Taxonomy into the structure of a classroom can provide clear objectives for both the instructor and the student (Armstrong, 2016). According to a group of cognitive psychologists, curriculum theorists, and assessment specialists, clear objectives could offer three main benefits. First, it helps the instructor plan and deliver appropriate instruction. Secondly, it helps design valid assessment tasks and other strategies. Finally, it ensures instruction and assessment are aligned with objectives using the taxonomy (Armstrong, 2016).

Traditional Learning

Traditional lectures involve faculty members delivering material to students who take on a passive role in learning. One example of is how Microbiology classes are taught in medical school in India (Patil & Karadesai, 2016). Students in a passive role are focused more on factual recall rather than actual reasoning. Traditional learning classes only reach the first level of Bloom's Taxonomy, which leaves room for improvement (Patil & Karadesai, 2016). These restrictions can hamper learning overall but may be addressed by altering the class structure.

Passive learning in traditional lecture classes relegates the lecturer to a purely explanatory role and limits interaction (Yoder & Cook, 2014). In some cases, traditional learning simply means learning in a face-to-face environment. For example, Kuyatt and Baker (2014) showed that combining face-to-face lectures with lab activities did not develop the students' spatial anatomical relationships in three dimensions (Kuyatt & Baker, 2014). They found supplementing the face-to-face lecture with a 3D online component improved spatial anatomical understanding.

Alternative Pedagogy Examples

Learning in social and behavioral sciences can be improved with non-traditional instruction. For example, a study compared two college psychology classes with similar numbers of students. One of the classes was taught traditionally, while the other was augmented by the addition of guided notes, which provided a more active style of learning. Students filled in key concepts necessary to fully understand the material during lecture (Williams et al., 2012). Grade improvements up to a letter grade (8.16%) were seen in the tests taken by students who received guided notes.

Another comparison was made between traditional classes and a fully online version of a psychology class (Lyke & Frank, 2012). Using the weekly quizzes taken by the students, as well as satisfaction surveys, the two types of instruction were compared to see which was more effective and garnered more satisfaction from the students (Lyke & Frank, 2012). Both classes were of equal size to avoid sample size bias in their results. The performances on weekly quizzes were not significantly different from each other. However, the satisfaction of the online course and of the instructor was lower when compared to the traditionally given class (Lyke & Frank, 2012). The authors were quick to point out that satisfaction may be affected by many variables related to the learning environment. For example, technological issues can impact the students' experience, which results in lower satisfaction scores for both the instructor and for the course.

Traditional lectures at pharmacy schools were also compared with an alternative structure for classes. In this study, 101 students were given courses that emphasized team based learning; students were involved in group projects that employed active learning while being self-directed (Frame et al., 2015). As they progressed to their second semester, students reverted to a traditional style lecture (Frame et al., 2015). Students were given surveys to assess which style of class they preferred at the end of the year. The majority of students preferred team based activities rather than traditional activities.

Another cohort of pharmacy students was involved in a comparison between traditional lectures and abbreviated lectures with a focus on case studies (Marshall et al., 2014). In this two-year study, students received a lecture on osteoarthritis using the abbreviated format in one semester and in the following semester they attended a traditional lecture on gout (Marshall et al., 2014). During the following year, a new cohort of students received instruction in which the styles were switched. The effectiveness of each was determined using pre and post class assessments, case questions, and exams (Marshall et al., 2014). The incorporation of abbreviated lectures and extended case studies proved to be beneficial for the osteoarthritis lecture, as the post class assessment returned higher scores with the case study class compared to the traditional class. The same results were observed with the gout lecture. However, performances on exams were equal from one class type to another (Marshall et al., 2014). These results indicate that smaller lectures with extended time spent on case studies improved student satisfaction of the lecture content given, but did not improve their performance on the summative exams towards the end of the course.

Despite the move toward alternative style lectures over traditional ones, there are cases in which traditional lectures are more effective. One study compared a traditional lecture to an interactive television (ITV) class, which reaches a wider audience (McCall et al., 2013). By collecting student ratings on instructors across 331 traditional courses and 125 ITV courses, the effectiveness of both styles were observed. The results showed the students favored traditional lecture over its counterpart (McCall et al., 2013). However, there was a major caveat to these results. McCall and his colleagues mention that although the majority of students preferred a traditional lecture, their reasons behind their selection were unclear. For example, the instructors delivering ITV classes may not have been adequately trained, which would create a sub optimal experience for those attending the class. The potential for technical issues affecting the experience for those students taking the ITV classes was also something to consider (McCall et al., 2013).

Zahid et al. (2016) also compared the effectiveness of Problem Based Learning (PBL) to traditional learning. Problem based learning focuses more around learning through problem solving, rather than rote memorization in a traditional class. However, despite the benefits of Problem Based Learning, the effects on theoretical knowledge have been inconclusive. Zahid and his colleagues (2016) argue that a lack of theoretical knowledge could be explained by the way this knowledge was assessed. Multiple choice question examinations, most commonly used to assess student knowledge, only test for basic cognitive skills, which do not fully explore the depth of learning offered via PBL. As a result, this comparative study between a traditional lecture and a PBL lecture used both multiple choice questions and an objective structure clinical examination, which gives students a variety of scenarios to apply their learned material (Zahid et al., 2016). Using both versions of assessment, the results showed that the PBL students outperformed the traditional students. PBL classes had more students score in the 80-90% range, and fewer students in the 60-69% range than their counterparts (Zahid et al., 2016). Involving the students in ways beyond didactic lectures could lead to improved performance by the students, reinforcing the idea of incorporating more levels of Bloom's Taxonomy in order to enhance learning.

One potential barrier to schools adopting new pedagogies could be cost. A study was conducted to measure the actual costs of running a traditional class versus Problem Based Learning. Hypothetical classes were created via questionnaires to 23 faculty at the University of Sharjah to estimate the faculty educational activities required for a subject based (Traditional) class and a problem based class (Hamdy & Agami, 2011). Faculty Educational Activities, or FEA, were used to determine the number of faculty and the amount of hours needed to create content for the class for each student. The results showed that problem based learning did not require more faculty over its traditional counterpart, nor did it require more hours of work from these faculty. As a result, Hamdy and Agami (2011) concluded that the costs of an alternative style classroom are roughly equal to those of a traditionally taught class. Although the costs were the same, the enhanced quality of education seen in a PBL classroom leads to the development of higher learning for students as well as an improvement in the teaching skills from faculty.

Some studies have taken traditional labs to include those who use a “cookbook” routine with a set of instructions for students to follow for each activity. One study compared the responses of students on a cookbook laboratory course and a research based laboratory course (Brownell et al., 2012). The research based lab course involved a single, large, longitudinal research focus; research questions with unknown answers; student determined experimental designs; and encouraged collaboration amongst students (Brownell et al., 2012). Twenty students were taken from each style of lab and given questionnaires and interviews regarding their views about their respective labs. The results showed that the twenty students who took the research based lab felt more positive about research in general, had higher self-confidence in lab related tasks, and had increased interest in pursuing future research in comparison to students in a cookbook laboratory.

It is important to note that any lecture or laboratory course that incorporates “cookbook” style activities should not necessarily be relegated to an inferior status. Alternative teaching styles can be added to a traditional lab in order to strengthen the quality of learning. For example, the addition of guided notes to a classroom that incorporates cookbook style activities can offer the benefits of active learning without the removal of the activities already in place. Many innovative pedagogies do not require an extensive reworking of traditional class structure. The addition of an activity can suffice. The focus should be on improving education based on Bloom’s Taxonomy.

Any change to the difficulty or intensity of a course can be considered an alternative to a traditional course. Kuscera and Zimarro (2010) define an intensive course as one with an accelerated pace due to a variety of changes including increased writing and reading assignments, and increased content. Though the number of accelerated programs is expected to increase due to growing demand, they are often met with increased criticism (Kuscera & Zimarro, 2010). Many academicians claim that an accelerated pace compromises learning, making it less effective than a traditional course taught at a slower pace. A growing body of research suggests otherwise; evidence shows that intensive courses result in improved learning outcomes when compared to a traditional slower paced course (Kuscera & Zimarro, 2010). For example, Kuscera and Zimarro (2010) conducted student surveys to rate the effectiveness of intensive vs. traditional classes. Surveys were applied across all subjects at a large, state university, and the data was then normalized to reduce possible variables that might skew the data. T-tests were used to determine which variables from the survey were a best fit to observe the effectiveness of the instructors and the course (Kuscera & Zimarro, 2010). The results indicated that there was no difference in instructor effectiveness between both styles of courses, but there was a difference in course effectiveness between the two. Students rated the intensive courses significantly higher ($P<0.032$) than the traditional courses (Kuscera & Zimarro, 2010). These results support the earlier argument that intensive courses can enhance learning by increasing the rigor at which material is delivered.

Flipped Classroom Model

Traditionally taught lectures and their accompanying laboratory sections have the potential for improvement based on Bloom’s Taxonomy; thus, exploring alternatives for conducting a class can improve learning for the students and enhance their performance. The purpose of this study was to focus on a particular pedagogy, the flipped classroom model. In essence, a flipped classroom involves a class where students go through much of the lecture material prior to in-class meetings (Baepler et al., 2014). As a result, a larger portion of actual class time is devoted to activities to solidify what students have learned through the online lecture. This flipped format was applied to the laboratory sections for Anatomy and Physiology courses at the University of Texas Rio Grande Valley.

The flipped classroom format has been used in a wide variety of subjects and grade levels. For instance, the flipped classroom format was applied to a high school trigonometry class. Over a six-week period, a control group was taught traditionally and an experimental group was taught using the flipped classroom format; assessment was conducted using pretests and posttests (Bhagat et al., 2016). Course interest surveys were also given to gather students' feedback on the different styles of teaching. The results showed that the flipped classroom students performed better in the posttest than their traditionally taught peers. Furthermore, all students in the flipped classroom reported high satisfaction ratings with the course (Bhagat et al., 2016). The enhanced performance and satisfaction was believed to be a result of the students in the flipped classroom being able to learn at their own pace by watching lectures given online prior to meetings in class.

Blended classes combine flipped and traditional classrooms, and offer the best of both. Traditional lecture time is reduced without being completely replaced and the remaining lecture is delivered online (Sajid et al., 2016). In one study (Sajid et al., 2016), a control group of medical students was taught pathophysiology and therapeutics traditionally in the spring semester of 2014. The following spring semester changed a portion of their lectures into Power Point files with voiceovers recorded and uploaded online (Sajid et al., 2016). Questionnaires were given to students to evaluate their respective courses, and summative assessments from both courses were compared to determine which cohort performed better. Sajid et al, (2016) found that there was no difference in performance, the students, however, showed a significant preference for the blended learning class over the traditional classes. This demonstrates an increase in student satisfaction through the encouragement of independent learning combined with teacher-student interaction in class, while keeping a tailored pace for each students' needs.

Morgan et al., (2015) found similar results in a flipped gynecology course at another medical school. The flipped portion of the class was a series of ten-minute videos with annotated notes and narrated Power Point presentations given prior to class. In class, students focused on case based discussions using computer software for a reduced time (Morgan et al., 2015). The students were given questionnaires regarding the flipped course; gynecological oncology exam scores from the US National Board of Examiners were used to compare the effectiveness of the flipped course to past courses taught in the traditional manner across the United States. Students were very positive regarding the flipped course, noting that both major segments (online and in class) of the reformatted course were helpful (Morgan et al., 2015). However, performance on the gynecological exam did not differ statistically from national averages. Although there was no difference in performance, the students preferred the more active style of learning in the flipped format and its time efficiency.

There have been cases where the flipped classroom model also improved the performance of the students while maintaining high perception ratings compared to a traditionally taught classroom (Memon et al., 2016). Medical students taking Neuroanatomy in their second year were split into 6 groups. All students received lecture in the traditional manner, followed by the flipped version of the class in small groups (Memon et al., 2016). Case scenarios were provided to the students prior to meeting with their small group. Questionnaires and summative exam scores were used in assessing the flipped classrooms effectiveness. Ninety-six percent of students believed the flipped classroom was the better approach, and more importantly, the average exam scores also increased to a statistically significant degree based on unpaired t-test results where the flipped cohort of students scored an average of 52.02, where the traditional cohort scored an average of 44.44 (Memon et al., 2016).

Blended learning has eased the transition from a fully traditional to a fully flipped classroom for some courses. For instance, an operation management course targeted to business students was offered using blended learning (Prashar, 2015). Prior literature on blended learning with the use of technological aids supported the potential of this method based on the nature of the business courses offered. This course encouraged solving real life business problems in multiple ways and were flexible, giving students the freedom to tackle scenario-based questions in a realistic fashion. This class transitioned into a flipped class format that incorporated this method in several class meetings and an exam was given to assess learning at the end of the course (Prashar, 2015). Students participated in focus groups to give feedback on the flipped classroom lectures offered periodically through the term. The exams showed that students ranked the flipped classroom highly on innovation and involvement, but the flipped classroom students also gave negative feedback on the unpredictability and unstructured form of it (Prashar, 2015). This study provided valuable insight in terms of the benefits and limitations of the flipped classroom model.

Flipped classrooms have also been implemented in pharmacy schools to great success. Koo et al. (2016) implemented the flipped classroom model in Integrated Pharmacotherapy I, a fall semester course for second year students. The flipped class involved an online portion with pre-recorded lecture videos and assessment questions to be completed before class, while in-class activities were left to focus on clarifying and applying concepts that were introduced online (Koo et al., 2016). Final averages and examination scores were used to assess student performances before and after flipped classroom implementation, and pre and post-course surveys were given to students to determine their satisfaction with the flipped course. Overall, student performance was improved under the flipped class, and a mainly positive opinion on the course was maintained throughout the surveys collected. One important note was a shared concern about the workload and time required for the flipped class, which the authors point out could indicate a limit to self-regulated learning that should be addressed in future iterations of the class by providing useful study tips beforehand (Koo et al., 2016).

The flipped classroom format can also be used in conjunction with technology to further improve its efficacy. In a study of pharmacy students, an online lecture before class was combined with a classroom quiz using “Poll Everywhere”, a software package that enables an instructor to deliver questions that can be responded to using smart devices such as phones, tablets, or computers (Gubbiyappa et al., 2016). Questions can be assessed immediately as the poll results come in, which enables the instructor to address student understanding as they attempt to analyze the material covered beforehand. This method was assessed for its effectiveness by comparing students’ examination scores to their quiz scores through Poll Everywhere. A questionnaire was also given through the same software to record student satisfaction with the flipped format. The students who gave poor reviews tended to obtain lower grades than those who gave the class a positive review (Gubbiyappa et al., 2016).

Other studies have taken place that focus on observing the effect of flipped classrooms on higher levels of learning based on Bloom’s Taxonomy. One study tested the flipped format’s effectiveness on enhancing creativity within their education students (Al Zahrani, 2015). Advancing technology provides the opportunity to enhance creativity due to the enhanced offering of visualization (Al-Zahrani, 2015). Specifically, computer programs allow students to break down concepts learned online and build new ones in part to their ability to revisit lectures multiple times. The ability for the student to work on learning at their own pace enables them to focus and learn in unique ways, which can further facilitate creativity (Al-Zahrani, 2015). A control classroom taught traditionally was given simultaneously to a second group of students in a flipped classroom. A creativity test was created to assess their novelty, flexibility, and fluency in the generation of new ideas based on their learned material. A survey was also given to students in the flipped classroom to provide feedback on the course. Creativity scores were higher in all three major categories from the flipped classroom. Student surveys revealed that they were highly to moderately satisfied with the flipped course. However, some students' surveys showed that students believe the flipped classroom to be more difficult (Al-Zahrani, 2015). The perceived increased difficulty is corroborated by other studies done on flipped classrooms with a similar recommendation of encouraging a higher level of preparation from students (Al-Zharani, 2015).

The flipped model format has also been used for graduate-level education courses (Moran & Milsom, 2014). The implementation of the flipped model was the result of prior student feedback that criticized the lack of real world applications of the learned material, and the lack of preparation from students on assigned readings (Moran & Milsom, 2014). Student surveys were given out at the middle and end of the semester using the flipped classroom to determine how beneficial the new format was at different intervals of the course. The small sample size (15 students) prevented any statistical tests on the data, so it was presented as descriptive data

(Moran & Milsom, 2014). In-class activities in the flipped model were reviewed positively, with pre class online activities rated lower, but still positive overall (Moran & Milsom, 2014). Some of the frustrations from the pre-class online activities were based on the inability of the students to work in groups as they do in class and observing these tasks as “assignments” rather than materials used to study (Moran & Milsom, 2014). Despite this, the students also admitted that the pre-class assignments made them more accountable for their own readings and also enhanced their preparation for in class assignments.

The flipped classroom model was applied in a foreign language course for third year students (Chen et al., 2014). Students had an online portion of the class with assignments and lectures regarding the upcoming class meeting. In class, the meeting was divided into three segments: a student centered segment, a teacher centered segment, and a practice exercise segment (Chen et al., 2014). By allowing a student-oriented section, the students were allowed to teach other and were encouraged to actively discuss any difficulties with the material. The teacher led section allowed additional explanation concerning the most notable issues and allowed further practicing by the students. The final section involved practice questions devised by the students and shared with the class followed by a presentation over the covered class material (Chen et al., 2014). Examinations given at the end of the semester were compared to the grades from a prior semester using a traditional method to determine which was most effective. The exam averages were five points higher for the flipped format and students reported higher satisfaction with the new method (Chen et al., 2014).

Flipped Classroom Model Used In Sciences

The use of the flipped model in an introductory course, such as general biology, provides an interesting look at impact on students. Typically, these students only prior experience with biology would have been their high school courses. One study involved two sections of a general biology I course taught traditionally and flipped simultaneously by the same instructor (Heyborne & Perrett, 2016). The flipped course and the traditional course shared the same overall schedule and lectures, as well as homework sets, quizzes, and exams. The major differences were the online availability of the lectures for the flipped course, as well as team-teaching, modeling, discussions, problem sets, and videos to be viewed exclusively by the flipped lab and reduced lab time (Heyborne & Perrett, 2016). The difference in student performance between both courses was not significant and student feedback from course surveys was also mixed. However, those students in the flipped course reported better overall perceptions of the course in comparison to their peers in the traditional course (Heyborne & Perrett, 2016). The mixed results of this study emphasize the need for careful planning when implementing a flipped classroom in an introductory course with students who are less prepared for a university level workload.

In addition to introductory biology, one potential application for the flipped format lies within the accompanying laboratory sections of other biology courses given at the freshman and sophomore level, such as Anatomy & Physiology. While faculty members may be hesitant to alter their methods in lecture sections, the lab section can be more malleable and allow room to use and perfect alternative methods. The flipped format can be applied by focusing on the addition of online content. Short lectures and assignments can be posted online for students to complete and study before lab meetings. Moreover, as the literature suggests, this form of active learning can improve student performance and satisfaction, all the while leaving the lecture section untouched.

Past studies reveal varying levels of success when implementing the flipped classroom format. The degree of integration into the course, and which course is flipped, affects the efficacy of the format. Furthermore, the methods of testing the effectiveness of the flipped classroom format have also been limited. Sample sizes are usually small, while data collection tends to run over the course of a single class or semester. Nonetheless, the beneficial nature of the flipped classroom is well known and can be further explored to define how and where this format is best applied.

Purpose Of The Study

The University of Texas Rio Grande Valley has two main campuses, one located in Brownsville, Texas and the other in Edinburg, Texas. As of Fall 2015, total enrollment of the school reached over 28,000 thousand students. Over 19,000 students were undergraduates of which 5,000 students were new undergraduates. This university serves a unique demographic, as it is a predominantly female, Hispanic student population coming from an economically disadvantaged area. The two largest metropolitan areas, Harlingen-Brownsville and McAllen-Mission-Edinburg, ranked 1 and 2 respectively on a list of America's poorest cities using data from the 2011 US Census. Furthermore, many of the incoming freshmen to the university are also first generation college students. Consequently, the location of this study will provide valuable insight into the effects of alternative pedagogies to underserved minorities in their first years in college.

This study had two aims. First, to determine whether the incorporation of the flipped lab affected student performance in the laboratory. Second, to determine whether incorporation of the flipped lab affected their performance in their respective lecture sections. Lab sections are meant to reinforce material already covered during lecture sections. By introducing flipped classroom model in the laboratory, student performance can be improved and quantified via improvements in their grades. In turn, the knowledge put to use in lab can prove to be helpful for summative assessments in lecture, which can cause the benefits of the flipped lab to transfer over to the lecture classroom as well.

CHAPTER II

REVIEW OF LITERATURE

The idea of redesigning traditionally taught laboratory courses was advocated long before their effectiveness was researched. In 1960, the Commission on Undergraduate Education in Biological Sciences recommended, “The best use of the laboratory in undergraduate instruction is to engage the student in the process of active investigation” (Brownell et al., 2012). The push towards active learning resulted in many colleges trying many alternative pedagogies, such as project based learning or a flipped model. Although they have been implemented to varying degrees of success, those who have attempted to change their style of teaching are aware of the shortcomings of traditional learning.

Advances in technology have also enabled the increased application of alternative pedagogies in classrooms and laboratories. On a large scale, some universities are adopting what are known as MOOCs: Massive Open Online Courses that offer online lectures to thousands of students at a time (Waldrop, 2013). These courses are believed by some to be a revolution in higher education; however, the detractors of online learning point out that MOOC lectures are useful for conveying facts, formulas, and concepts, but lack the ability to actually put knowledge in to practice (Waldrop, 2013). Furthermore, MOOC’s also have a low completion rate, with around 7-10% of students completing a MOOC course (de Frietas et al., 2015). Technology is now advancing through the use of smart phones and immersive gaming software to allow the use of their gained knowledge alongside online-based lectures (Waldrop, 2013). Laboratory sections that accompany a lecture section offer the hands-on experience that students need to reinforce their lectures. However, there are certain cases where universities do not have the capability to offer these accompanying labs. MOOC can help mitigate the downside of this by offering remote access to laboratories in other locations, such as Open University from the UK using spectrometers and telescopes from Spain (Waldrop, 2013). Smartphones also have been used in physics courses to capture video footage of objects in motion. By using open source software, students can apply theories to the data collected, while also creating video presentations and uploading them online for peer evaluations (Waldrop, 2013). Advancements in technology and their educational applications could prove to be very helpful in addressing problems seen over traditional classrooms. Incorporating these online components into a course is one way to improve learning.

Online learning is based on three main components: hardware, software and "underware", which is the pedagogy that determines the development of the online section of a class (Ye & Herron, 2010). The teaching technique to be employed should be the foundation for all assignments and learning materials, as well as the manner in which students are expected to interact with the materials (Ye & Herron, 2010). The quality of an online classroom can be maintained with student learning outcomes in mind, so it is important that teachers select appropriate materials that align with these outcomes in order to maximize effectiveness. Teachers need to be aware of what types of assignments work best according to their style of teaching, and build the course around the pedagogy selected to enhance its effectiveness.

Many institutions opt to use a hybrid approach, which incorporates both online and traditional aspects of a course. For those institutions with the technological infrastructure to support this type of class, it offers the flexibility and efficiency of an online class with the advantages of a traditional hands-on class to give students the best of both worlds (Sowan & Jenkins, 2013). Caution should be applied, however, especially for students who are accustomed to traditional learning that are new to taking a hybrid class. The design of the class needs to take into account students internet access and its reliability, as well as the computer literacy of the student (Sowan & Jenkins, 2013). It is also important to use the online aspect of the classroom as a way to enhance collaboration and learning for students, rather than just a way to store lectures online (Sowan & Jenkins, 2013).

Any online or hybrid class should be designed around modern pedagogical principles and theories of learning. One such principle is the constructivist principle, applied to many cases of learning through the internet (Sowan & Jenkins, 2013). The constructivist theory is based on the student constructing their own knowledge through interaction with others, reflection of the content, and making connections with content learned in the past (Sowan & Jenkins, 2013). As a result, this theory of learning focuses more on the dialogue, or two way exchanging of information from students and instructors, rather than the simple one-way transmission of information seen in didactic lectures. This newfound role of an instructor, who directs learning by guiding students to construct the appropriate knowledge in a course, is one of the pillars of a flipped model classroom (Sowan & Jenkins, 2013). A hybrid class shares much in common with the flipped model, so any feedback and improvements done to a hybrid class may also be applied to a flipped class, especially those concerning design and subsequent ease of use.

Understanding the design of the class and how it is taught is an increasingly common focus of behavioral research. Different strategies that have arisen from behavioral teaching research have demonstrated that student deficits can be the result of a problem within the teaching environment instead of a problem originating from the student (Williams et al., 2012). Active student responding is one potential solution to a faulty teaching environment. An online lecture can be designed in a way that guides the students towards relevant information, while leaving key concepts to be learned in person during the scheduled meeting times. By applying improvements from other alternative pedagogies, the efficacy of the flipped model can be improved for a variety of courses.

Improvement of the flipped model can allow it to be applied on other types of courses, such as a laboratory. Laboratories are extremely important in providing a hands-on experience for science courses, especially for introductory courses taken during the first two years of an undergraduate student program. In activity-based labs, students practice the skills obtained through lecture and allow learning to go beyond simple factual recall. However, students are notoriously underprepared for these courses coming from high school. According to average ACT scores, only 26% of all incoming freshman students were academically prepared to take a freshman biology course (Moore, 2008). This leaves a lot of room for growth in not only traditionally taught classrooms, but laboratories as well.

Issues with student preparation can also cause difficulties for instructors. For instance, students at Arizona State University West who took the Life Sciences route, traditionally encountered problems with their curriculum at all levels, from freshman level biology courses to upper level biochemistry courses (Deutch et al., 2008). Based on surveys given to students, many had issues with time management, as well as overall difficulties with learning the material (Deutch et al., 2008). In response to the feedback, the Life Sciences department at ASU West incorporated tools such as making PowerPoint lectures available online for students to use prior to class; guided notes for use in class; and additional study materials such as homework problems, quizzes, and summaries (Deutch et al., 2008). The results showed that alternative pedagogies could be used to improve the performance of students and amending the differences seen from students with different educational backgrounds. By providing materials online as an enhanced model, students were allowed extra time to work on their reading and writing skills, which in turn helped their mastery of the material in class (Deutch et al., 2008). The benefits of online course components can extend to skills outside of the classroom, as well as potentially improving performance on standardized examinations.

The application of an online component for any class or lab section can vary depending on the course. The degree of online integration can also vary based on the instructor and depending on the needs of the class. For example, human anatomy and physiology classes are undergoing an expansion due to increased demand for undergraduate students to take these courses prior to professional schoolwork in a health related field (Kuyatt & Baker, 2014). Thus, many universities are now offering the class; however, associated costs with human cadaver dissections, lack of dissection materials, and a lack of qualified anatomy instructors may cause universities to look for alternatives for the human cadaver dissection. One such alternative would be to include online activities for the class. Online classes offer increased timing flexibility, which enables more students to enroll, and rapidly advancing technology using 3D models can enhance students' spatial relational comprehension similar to actual dissection work on human cadavers (Kuyatt & Baker, 2014).

The online class should be designed and evaluated with both instructor and student perspective in mind. One of the most effective methods of creating an online class is creation and maintenance of an engaged learning environment on all aspects of the course (Kuyatt & Baker, 2014). An engaged learning environment uses instructional texts and visuals all geared toward building skills and knowledge in long-term memory (Kuyatt & Baker, 2014). Learning in any area of study, including anatomy and physiology, uses simple practice that leads to interactive practice, which in turn leads to expertise (Kuyatt & Baker, 2014). The use of written activities provides simple practice, while hands-on activities such as dissections can provide the interactive practice. All in all, using a variety of assignments in the class or lab that are focused on making the meetings more interactive can enhance the learning for the students.

The transition of higher education toward use of more technology is well underway. There are many online institutions that are accessible to a potential student. These include for-profit institutions such as the University of Phoenix, DeVry University, and Walden University (Bristow et al., 2011). But there are also an ever-increasing number of brick-and-mortar universities such as Boston University, Clemson University, University of Florida, Texas A&M, and the University of Notre Dame that offer online classes or some form of distance education (Bristow et al., 2011). By the year 2000, it was estimated that over 75% of colleges and universities offered online classes. Four years later, it was estimated that nearly 90% of these institutions offered online classes (Bristow et al., 2011).

As a whole, the benefits of an online class have been well established in the literature concerning the current standing of learning in higher education. A flexible course offered online can be just what many students are looking for as a counter to overcrowded campuses and increasingly difficult time commitments (Lyke & Frank 2012). Institutions can be much more efficient in using resources when online classes are offered, and students could benefit from increased critical thinking, leadership, communication, and problem solving skills (Lyke & Frank, 2012). Despite this, some faculty, administrators, and students still show resistance to the idea of online learning. Common criticisms include increased isolation from peers, lack of engagement, and lack of technical support for those who need it (Lyke & Frank, 2012).

These concerns can be addressed by simply opting for a style of classroom that aligns with the hybrid approach of teaching. Isolation and a lack of engagements can be resolved by a flipped model classroom, which offers the opportunity for students to both meet in person during class and use various materials. Technical support can be offered, in part, by the instructor trained in the software and underware applied in the course, as well as support offered via any learning system software used by the campus. More often than not, Blackboard™ is the learning management tool of choice. Over 75% of all universities and nearly half of all K-12 schools incorporate some form Blackboard™ into their curriculum (Empson, 2014). This not only solves the technical support issue, but also allows for easy implementation of a hybrid approach to a class because the system may likely be in place.

Modified Lectures In Alternative Pedagogies

Flexibility offered by advancing technology combined with advancements from alternative pedagogies provide a solid foundation upon which higher education can improve. There are many types of pedagogies and the ones used in current research are learner oriented, rather than lecture oriented that is common in a traditional classroom. One of the more conservative approaches of learner-oriented classrooms is known as Abbreviated Lectures. In this style, lectures are drastically reduced from an average 70% of a traditional class, to only 30% of a class (Marshall et al., 2014). The rest of the class focuses on case studies involving questions from the lecture, which are often absent from traditional classes. This transitions learning into a more active role, which increases student recall of information as well as its applications.

Abbreviated lectures can be taken a step further using Case Based Learning (CBL), which is very similar to Project Based Learning (PBL). With both CBL and PBL, lectures are removed altogether and replaced by case studies or problems presented by the instructor. Both of these approaches promote active learning by utilizing real scenarios that students may encounter in their future careers (Patil & Karadesai, 2016). Using these cases or problems, students can link theory to practice by applying the knowledge they have gained to the problems presented by the instructor (Patil & Karadesai, 2016). Along with active learning, CBL and PBL both promote self-directed learning and reinforce communication, reasoning, and collaborative skills for students (Patil & Karadesai, 2016).

Both CBL and PBL play a role in making up the larger pedagogical approach known as Inquiry Based Learning (IBL). Inquiry based learning has been defined as a cluster of student centered approaches to learning that are driven by inquiry or research (Aditomo et al., 2013). Inquiry based learning can also be summarized by its overarching qualities, such as offering students a problem to analyze or data to interpret, which act as a catalyst for student engagement and participation (Aditomo et al., 2013). Overall, IBL emphasizes student centered learning where problems and cases drive the learning; the instructor serves as a guide for learning rather than the exposition of content (Aditomo et al., 2013). Inquiry based learning and its several forms support the concept of active learning and utilize it thoroughly by allowing students to address the cases or problems using their own knowledge and, with an instructors help, arrive at their own solutions and conclusions.

The freedom offered by IBL and its alternative approaches come with both supporters and detractors. Many detractors take issue with the lack of structure and guidance related to IBL. This group is unified behind the idea that instructors should lead students on concepts and other assignments instead of students discovering them or completing them on their own (Kirschner et al., 2015). Kirschner maintains that minimal guidance classes operate under two main assumptions: using problems offered in class is the best method for providing an effective learning experience; and the learning experience provided by in class cases or problems give the students the best opportunity to learn (Kirschner et al., 2015).

Alternative pedagogies, such as IBL, that involve minimal guidance fall in a spectrum that includes a variety of degrees of guidance. In some cases, students may grasp the wrong concept, but it is up to the instructor to guide them back toward the right concept. Kirschner et al. (2015) acknowledges that students with prior knowledge of the material can be successful in minimal guidance courses. However, he rejects instances where IBL is superior. Alternative pedagogies are rapidly changing and improving; with the aid of technology their use is expanding across many disciplines and used to great effect, both in terms of performance by students as well as satisfaction from changing to an active class from a rote lecture. Therefore, the search and active improvement of alternative pedagogies is vital for education to improve at all levels.

One such improvement in PBL/CBL would be Team Based Learning. It operates under the same principles as PBL or CBL, with added in-class assessments to elucidate “muddy points” in assigned readings prior to class (Frame et al., 2015). Once problem areas have been identified, students are split into teams. A mini-discussion takes place to explain challenging concepts, followed by a problem or case study presented to the group that allows students to use critical thinking skills to apply the information they learned (Frame et al., 2015).

The benefits of this approach are widespread, extending to both students and faculty. Students are exposed to active learning, which is related to deep learning. Through deep learning, student adaptability is enhanced, which can increase the retention of material. This is believed to be due to students understanding the material through use rather than simple memorization and reproduction on exams (Frame et al., 2015). Performance on assignments and examinations are improved. Teachers benefit by splitting students into teams, making the classroom easier to manage and making each interaction feel more personalized. Team based learning also enables teachers to push their lectures to an online format before class, which allows more time in class to work on assignments or assessments to address gaps in student knowledge (Frame et al., 2015). Team based learning is a prime example of the improvements that are possible in a minimally guided classroom, while providing a base to continue improving this alternative teaching method.

Some alternative methods of teaching are much more focused, which decreases their capability for widespread use, but increases efficiency for a few applications. An extreme example is the dialectic method of teaching. This method places particular emphasis on debates. Material is placed into two opposing sides with students tasked to defend each side of the argument using critical thinking in the hopes of understanding and learning more about each side and the dynamic relationship between the two (Nyatanga & Howard, 2015). This method works under two assumptions. The first is that students are somewhat informed of the topic and are able to explain some concepts from both sides of the debate. The second assumption is that the human mind best understands ideas that are split with two polar extremes (Nyatanga & Howard, 2015). As a result, this can be applied to a wide variety of disciplines (i.e., sciences, history, psychology) but it is limited to class discussions that are dialectic in nature. Still, this moves learning away from a passive to an active nature with students participating in discussions, which can improve the quality of learning in class.

Cooperative or peer assisted learning is another alternative pedagogy that is specialized yet limited in its applications. Peer assisted learning traditionally involves two students, one acting as a surrogate teacher to the other student who is usually a grade level beneath the teaching student (Asghar, 2010). However, there are instances in which two students of the same grade level can alternate teaching responsibilities; thus, both students benefit. This specific method is called reciprocal peer coaching. The students are accompanied by a tutor to guide them when necessary and reflect on their own learning while giving feedback to their partner (Ashar, 2010). Key elements to reciprocal peer coaching include clear interdependent goals for students, as well as individual accountability for both students (Ashar, 2010). This strategy encourages teamwork as both students work toward a common goal and assist their partners to reach the same end point. This particular method is effective for classes with hands-on learning such as a lab focused on clinical practices. Despite this, its effectiveness is mitigated by the fact it is best used for some formative assessments rather than a method to base an entire class around (Ashar, 2010).

Academic games provide another example of a limited alternative pedagogy. The use of games in classes offers an alternative formative assessment that allows instructors to make learning more accessible and interesting (Shiroma et al., 2011). Academic games can promote group work, help reduce anxiety, help identify weaknesses in student understanding of content, and provide an outlet for study guides for exam preparation (Shiroma et al., 2011). These games also provide ample flexibility in terms of presentation, as they can be used for a multitude of topics and can be based off of common games such as “Jeopardy” (Shiroma et al., 2011). Research has shown that using this strategy shows no significant difference in performance when compared to a traditionally taught classroom, but student perceptions were improved to a significant degree (Shiroma et al., 2011).

Active learning can take place in a classroom where there is a high amount of interaction between an instructor and a student. As a result, some alternative pedagogies focus on increasing potential interaction. Prime examples include the learning assistant program and peer assisted learning. Learning assistants are students who are in charge of facilitating discussions or providing guidance in assignments in large enrollment introductory courses (Talbot et al., 2015). Learning assistants are typically required to complete the course before becoming an assistant. In that way, they can use their prior experience in the same course to help their "near peers" (Talbot et al., 2015). Normally, a large enrollment class is taught traditionally, which includes the usual downsides seen in passive learning. Many of these classes serve as "gatekeepers" intended weed out poor performing students from upper level courses (Talbot et al., 2015). Many students' shortcomings are exacerbated by the nature of the class itself (i.e., large number of students, limited access to the professor). Student instruction and increased peer-to-peer interaction can increase satisfaction of students in the class, as well as their performance (Talbot et al., 2015).

Some alternative methods take a meta approach, such as holistic learning. Holistic learning operates under the premise that both teaching and learning should be integrated (Poindexter, 2003). Holistic learning emphasizes the use of many small innovations such as guided notes and case based studies, which assist learning and incorporate them into a larger strategy that helps both faculty and students (Poindexter, 2003). Ever-improving technological infrastructures of universities have allowed incorporation of alternative methods of teaching and learning, such as guided notes or flipped classrooms. In the holistic approach, both should be incorporated together; this is facilitated by the fact that contemporary students are much more open to the ideas of innovation in teaching and learning with the assistance of technology. The Baby Boomer generation faculty have mostly retired and been replaced by the Generation "X" cohort of faculty who were born through the late 1960s up to the early 1980s (Poindexter, 2003). This generation as a whole is thought to be more relaxed and adventuresome, which can allow the pursuit of alternative teaching methods and their eventual implementation into classrooms. Innovations in teaching and learning under a holistic approach have a higher chance of success if they are used simultaneously.

There is growing interest amongst scientists and science educators in the benefits of using active learning, specifically in how primary evidence, such as data, is used to construct scientific knowledge (Clark et al., 2009). Consequently, evidence based learning was developed out of the need to use evidence from real world research cases to build knowledge. Previously, schools have attempted to fill in the void by offering hands-on research classes for students. However, the large resource demands to run such classes prevented many institutions from offering them on a large enough scale for first and second year undergraduate students (Clark et al., 2009). Many universities offer journal clubs to discuss recent publications, but they are limited in size and usually involve upper level students only (Clark et al., 2009). Research deconstruction, involving undergraduate seminars that discuss current research, is one case of evidence-based learning. An invited faculty member presents a one-hour research seminar at the start of the semester. Over the course of four weeks, the instructor will go over approximately ten minutes of the seminar and deconstruct it with students to further enhance their understanding. This allows students to process the research piece by piece. Toward the end of a five-week module, they will have successfully deconstructed the entire seminar and then move on to another one (Clark et al., 2009). Student perception was high according to assessment data from the Classroom Undergraduate Research Experience (CURE) surveys, preferring the deconstruction method to traditionally taught cohorts (Clark et al., 2009). Use of current research alongside an increased emphasis on how scientific knowledge is constructed from cutting edge scientists, proved to be immensely helpful for undergraduates who normally struggle in these areas.

Other alternative teaching methods incorporate active learning by reorganizing existing activities. For example, some classes use the strategy known as the learning cycle. The learning cycle was originally developed for elementary schools, but was found applicable for many grade levels including university level classes (Allard & Barman, 1994). This strategy breaks up a class into three phases. First, the lecture material is presented as a problem or task. This represents the exploration phase, in which students explore a variety of options to solve the task. The second phase is the concept introduction phase. Using feedback from the exploration phase, the instructor can present and explain concepts that were explored during the first phase, as well as clarify any jargon that may have been used. The final phase is the concept application phase. Here, students use the concepts they have learned and apply them to a new, but related task or problem (Allard & Barman, 1994). Research comparing the learning cycle to traditionally taught classes shows that the students taught using the learning cycle exceeded or at least met the performance of those taught traditionally on all concepts (Allard & Barman, 1994). The difficulty with this method lies in its implementation. It requires a major reworking of a class's curriculum, as well as a learning environment that supports hands-on learning. It also necessitates an instructor that is willing to be a facilitator for learning instead of a dispenser of knowledge (Allard & Barman 1994).

All in all, research on alternative pedagogical methods shows a positive trend for increased student learning and either match or exceed the performance of its traditional counterpart. Despite its benefits, implementation of these methods may be difficult. Some methods, such as the learning cycle or inquiry based learning and its subsidiary forms, require extensive reworking of classrooms and require instructors to be trained for the role of a learning facilitator. This can hinder the ability of these methods to flourish in higher education, as some universities simply do not have the resources to make the transition. Faculty and students themselves can cause the obstacles preventing the implementation of these pedagogies. For example, academic managers criticized higher education in the United Kingdom when attempts to reform teaching and learning strategies didn't provide stable success (Newton, 2003). Staff were worried that teaching and leaning had become too "technocentric" or based around web programming and development (Newton, 2003). As a whole, detractors noted that the improvements of student perceptions in learning or their performance improvements may have happened without the use of alternative pedagogies (Newton, 2003).

Objective

Literature shows that alternative pedagogies have potential to improve learning across all education levels. Continued research on the effectiveness of these pedagogies is paramount in order to determine which is best, and when and where to apply them. For example, the flipped model has been applied to lecture classrooms, however, there is a scarcity of information on its effectiveness for laboratory sections in introductory biology courses. As a result, this study focused on the effectiveness of the flipped model on laboratory sections and its residual effects to related lecture sections. It was hypothesized that the flipped model would improve the performance of students across both formative and summative assessments for their lab sections, while also improving their summative assessment grades for lecture.

CHAPTER III

METHODS

Data Collection Overview

This study was a comparison between two lab-teaching styles. From Fall 2012 until Fall 2014, Anatomy and Physiology I and II labs were taught traditionally. During the Spring 2015 semester, the labs were converted to the flipped classroom model. Quantitative data in the form of course averages and lab grades were collected from 2012 to 2015. All data were edited to prevent identification of students. Outlying data points from students who dropped the course were removed from the data pool. This was determined by removing any data points that had no scores from the second lecture exam and onward, indicating that they were no longer active in the class.

Statistical Analysis

Data were compiled by semester and by year to compare performance of students in traditionally taught labs to those in the flipped classroom model. Statistical analysis software (JMP) was used to compare scores and grades of students in both styles of laboratories. One-way analysis of variance (ANOVA) was used on quiz grades, midterm exam grades, as well as final exam grades to compare course averages between years. Histograms were created for both labs and lectures by semester to determine averages and grade distributions before and after implementation of the flipped classroom model. Regression analyses were used to determine the relationship between overall lecture and overall lab grades both before and after use of the flipped classroom model. Grades were compiled based on whether they were derived from traditionally or flipped labs. Lecture grades were plotted along the Y-axis and lab grades plotted along the X-axis. Lecture grades were plotted as the dependent variable, as they depended largely on the grade attained in the lab portion of the course. Coefficient of determination was compared amongst overall grades from both lectures and labs before and after the flipped model was implemented.

Chi-square tests were applied to overall lab grades for traditional and flipped labs to determine if there was a significant change in distribution of letter grades. The larger number of data points for traditional labs was adjusted by finding percentages of students who received a letter grade and multiplying it by the total amount of data points in the flipped model. This allowed for an even comparison of letter grade distributions using the smaller data set obtained from flipped labs

Applying The Flipped Classroom Model To Laboratories

Traditional laboratories were used at the University of Texas Pan American, which was the legacy institution of University of Texas Rio Grande Valley. In a traditional laboratory, teaching assistants had near full control over all aspects of the lab. Teaching assistants created lectures, quizzes, and exams. In the laboratory, meetings would start by giving a quiz over the previous material. Quizzes had ten questions worth ten points each, with an additional two questions worth at least 5 points of extra credit each. Following the quiz, teaching assistants would lecture over the current material for at least 15 minutes. After the lecture, lab activities would take place (i.e., lab dissections, experiments, etc.). Exams were created by submitting a pool of questions written by teaching assistants, who would then choose their questions from the pool. Six questions would be added as extra credit, totaling up to an extra 10 points of extra credit for both the midterm and final exam.

Flipped laboratories at the University of Texas Rio Grande Valley used Blackboard™, an online learning service that provided access to course content for students enrolled in the respective anatomy and physiology courses. Lectures were replaced by pre labs, which included interactive online modules to be completed prior to laboratory meetings. Instructors used SoftChalk™ Cloud, a digital curriculum service that works as a companion application to Blackboard™ to create pre labs. These pre labs included various types of assignments, such as drag and drop questions for anatomical models, fill in the blank, crossword puzzles, or matching puzzles. Pre labs were graded, with a required passing grade of 75% or higher in order to gain admittance into the laboratory. Students who did not score 75% or higher could repeat the assignments in order to increase their score. However, some questions were not the same as their previous attempt.

Laboratory meetings were focused on conducting activities or experiments introduced in pre labs. Activities included identifying structures and their functions on models, use of microscopes to study histology, and dissections of various specimens. Teaching assistants in charge of the laboratory supervised activities and assisted students as needed, and interacted with students to test their understanding of material. Teaching assistants also ensured safety of students as they conducted experiments.

Laboratory meetings were concluded by a “quiz out”. These oral quizzes were given in groups and acted as formative assessments for the class. Teaching assistants asked a variety of questions pertaining to the weekly topic. In some cases, questions were directed to certain students to test their mastery of the material. This was used to identify students’ weaknesses, so the teaching assistant could direct students to study concepts where they did not perform well. These quiz outs gave students immediate feedback about how they performed in lab. The laboratory concluded with a ten minute timed post lab quiz, which was offered online. Quizzes contained an assortment of ten fill in the blank or hot spot questions, in which students were required to click on the appropriate section of a picture. These were also graded with detailed feedback released to students one week after the due date. Summative assessments in the form of midterm and final exams were given as a lab practicum in person and proctored by the teaching assistants.

CHAPTER IV

RESULTS

Exam And Quiz Grades

A one-way ANOVA applied to quiz averages from Anatomy and Physiology I and II (Figures 1 and 2), respectively. Quizzes were compiled by year with the 2015 data showing the flipped portion of the data. There was a downward trend in quiz averages (Tables 1 and 2), all of which differed to a statistically significant degree ($P<0.0001$). Both standard deviation and the standard error of the mean hit their lowest points when the flipped model was implemented, indicating a closer dispersion of data points and sample means around the population mean.

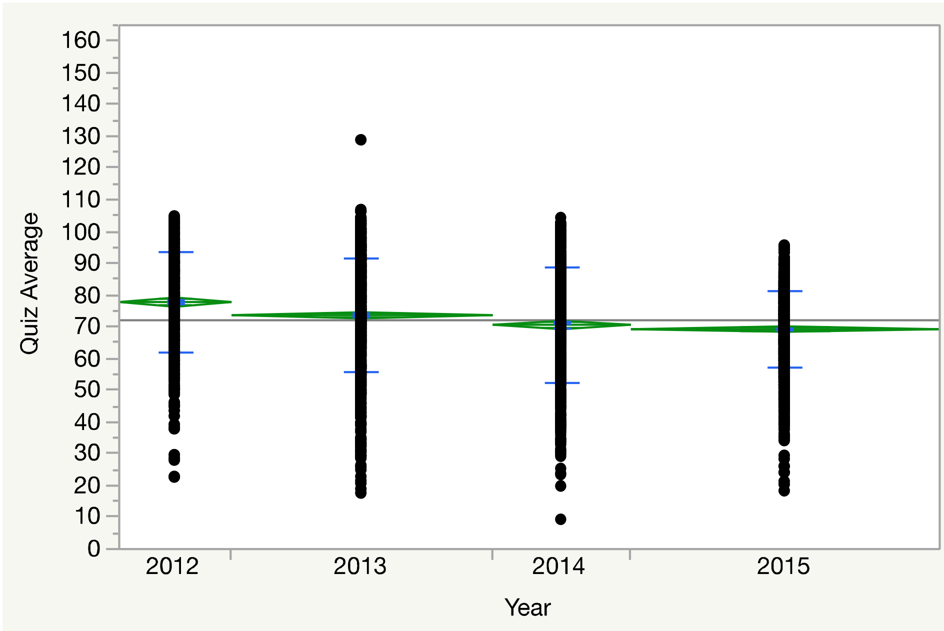

Figure 1: A&P I Quiz ANOVA. One-Way ANOVA applied to quiz anatomy and physiology I quiz averages, grouped together by year. F ratio of 38.59, with a P value less than 0.0001.

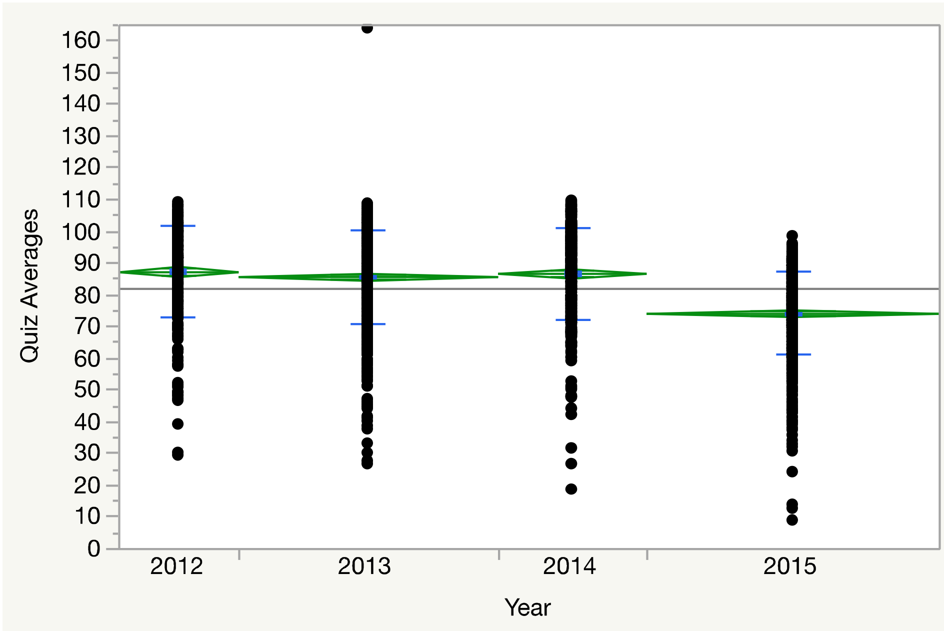

Figure 2: A&P II Quiz ANOVA. One-way ANOVA applied to anatomy and physiology II quiz averages, grouped by year. F ratio of 113.89, with a P value of less than 0.0001.

Table 1: A&P I Quiz Averages

Year	Quiz Average	Standard Deviation	Standard Error of the mean
2012	77.74	15.8	0.74
2013	73.59	17.73	0.54
2014	70.54	18.08	0.77
2015 (Flipped)	69.2	12.01	0.34

Quiz averages, standard error, and standard deviation grouped together by year.

Table 2: A&P II Quiz Averages

Year	Quiz Average	Standard Deviation	Standard Error of the mean
2012	87.17	14.58	0.85
2013	85.55	14.97	0.59
2014	86.59	14.31	0.75
2015 (Flipped)	74.08	12.94	0.48

Quiz averages, standard error, and standard deviation grouped together by year.

A one way ANOVA was used to analyze midterm averages (Figures 3 and 4). All years had differing midterm averages to a statistically significant degree ($P<0.0001$). The flipped model no longer decreased the standard deviation nor the standard error of the mean in comparison to traditionally taught laboratories (Tables 3 and 4). One way ANOVA for final exams show similar results in that all years had significant differences (P<0.0001) in final exam averages (Figures 5 and 6). Standard deviation and standard error vary year by year, potentially showing that the implementation of the flipped model had no effect (Tables 5 and 6).

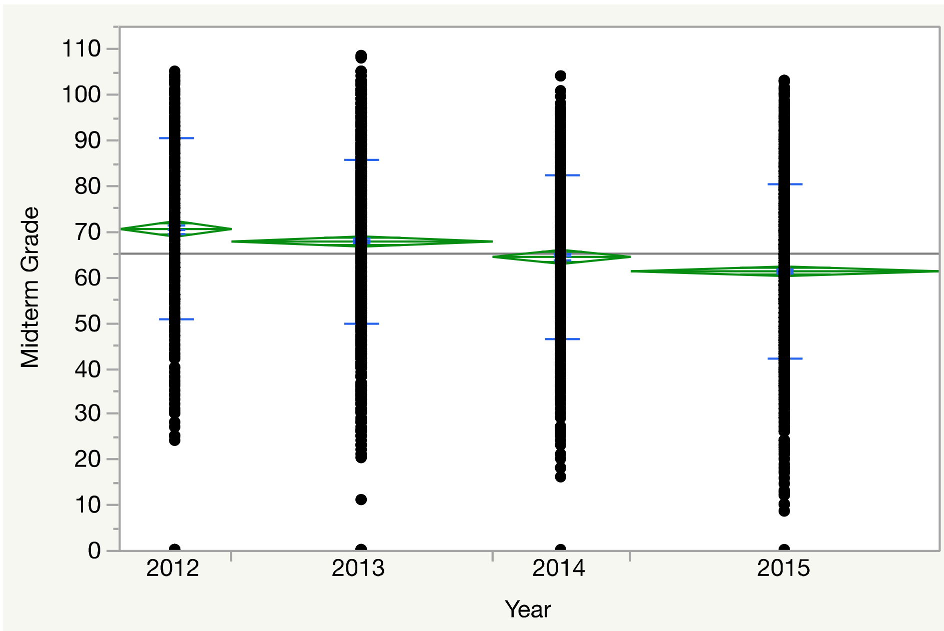

Figure 3: A&P I Midterm ANOVA. One-way ANOVA applied to anatomy and physiology I midterm averages, grouped by year. F ratio of 37.24, P value of less than 0.0001.

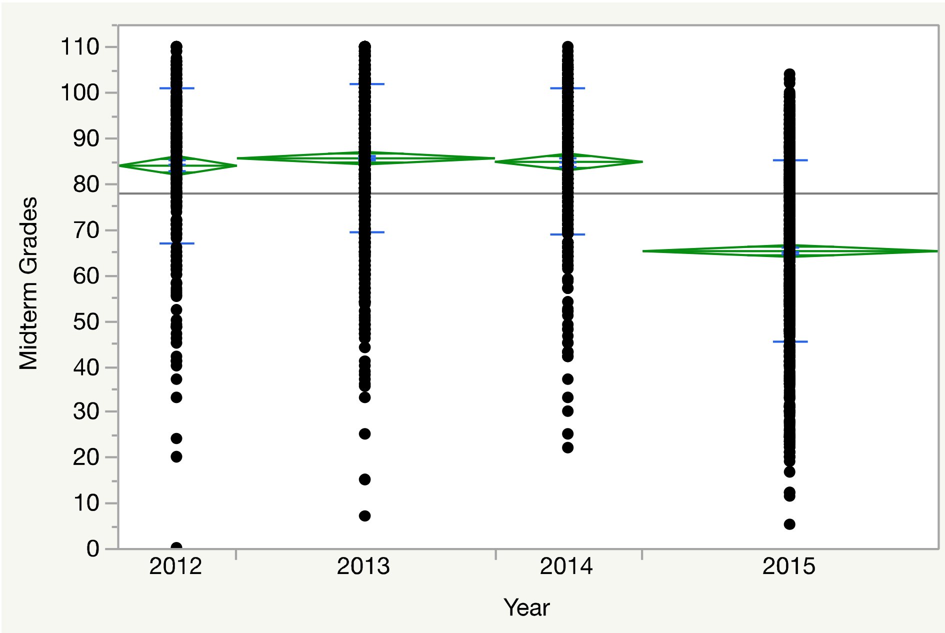

Figure 4: A&P II Midterm ANOVA. One-way ANOVA applied to anatomy and physiology II midterm averages, grouped by year. F ratio of 189.71, with a P value of less than 0.0001.

Table 3: A&P I Midterm Averages

Year	Midterm Average	Standard Deviation	Standard Error of the mean
2012	70.63	19.78	0.93
2013	67.88	17.91	0.55
2014	64.5	18.08	0.77
2015 (Flipped)	61.36	19.23	0.54

Quiz averages, standard error, and standard deviation grouped together by year.

Table 4: A&P II Midterm Averages

Year	Midterm Average	Standard Deviation	Standard Error of the mean
2012	84.12	17.06	1.00
2013	85.77	16.39	0.65
2014	84.93	16.16	0.85
2015 (Flipped)	65.39	20.03	0.74

Quiz averages, standard error, and standard deviation grouped together by year.

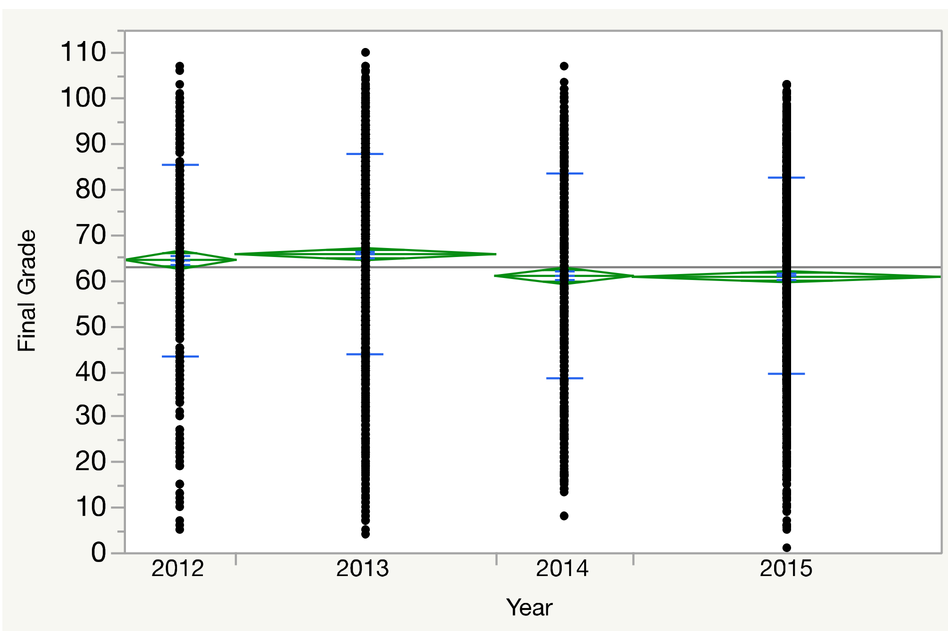

Figure 5: A&P I Final ANOVA. One-way ANOVA applied to anatomy and physiology I final averages. F ratio of 11.88, with a P value of less than 0.0001.

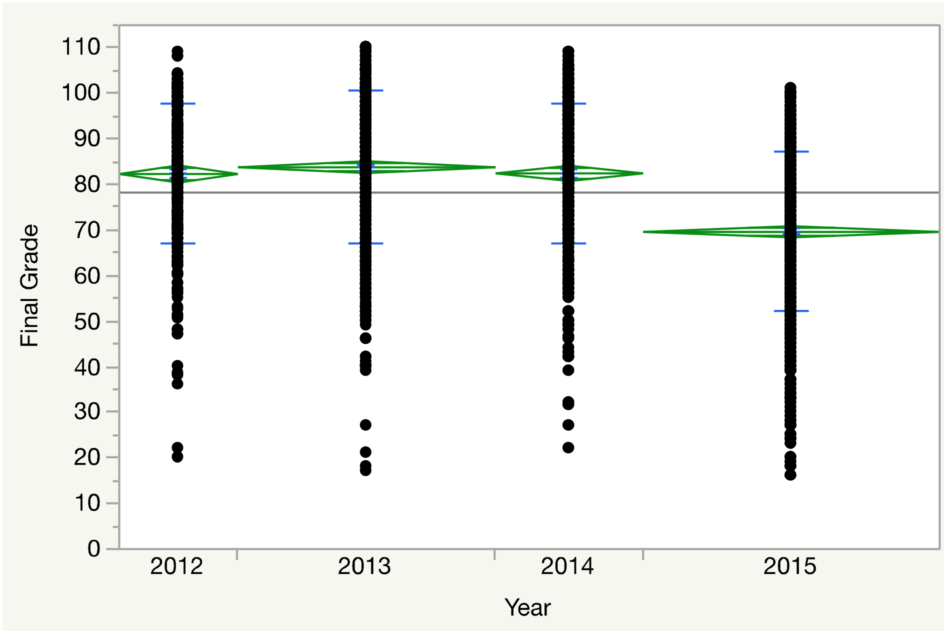

Figure 6: A&P II Final ANOVA. One-way ANOVA applied to anatomy and physiology II final averages. F ratio of 103.09, with a P value of less than 0.0001.

Table 5: A&P I Final Averages

Year	Final Average	Standard Deviation	Standard Error of the mean
2012	64.37	21.13	0.99
2013	65.59	22.18	0.68
2014	60.84	22.43	0.95
2015 (Flipped)	60.65	21.54	0.61

Quiz averages, standard error, and standard deviation grouped together by year.

Table 6: A&P II Final Averages

Year	Final Average	Standard Deviation	Standard Error of the mean
2012	82.28	15.39	0.90
2013	83.78	16.65	0.66
2014	82.44	15.33	0.80
2015 (Flipped)	69.60	17.43	0.64

Quiz averages, standard error, and standard deviation grouped together by year.

There was a decreasing trend in quiz, midterm, and final exam averages from traditional to flipped classrooms. However, these grades show a decline due to changes made to the assessments. In the traditional format, teaching assistants wrote quizzes and exams offered up to 20 points of extra credit on quizzes and up to 10 points of extra credit on exams. Often times, the extra credit questions had no relation to the course content, which proved to be an easy way to earn grade improvements. Extra credit opportunities were mostly removed in the flipped model. Quizzes no longer had extra credit questions, and both midterm and final exams only offered 3 points of extra credit. Grade inflation in the traditional lab could be at fault for the decreasing averages seen in the flipped labs. Indeed, some students scored above 100% when the extra credit was offered (see below).

Score Distribution

Lab grade histograms are used for Anatomy and Physiology I (Tables 7-12). Each figure displays one semester from Fall 2012 through Fall 2015. The last two figures (11 & 12) for Spring and Fall 2015 were under the flipped model format. The highest lab average of 80.26 was observed in the Fall 2015 semester under the flipped model format. The Fall 2015 semester also gave the lowest standard deviation and standard error of the mean, indicating a tighter dispersion of data points. Despite the decreasing averages with the removal of extra credit, more students passed the laboratory portion of the course. As a result, the lab averages increased even though the individual assessment averages decreased.

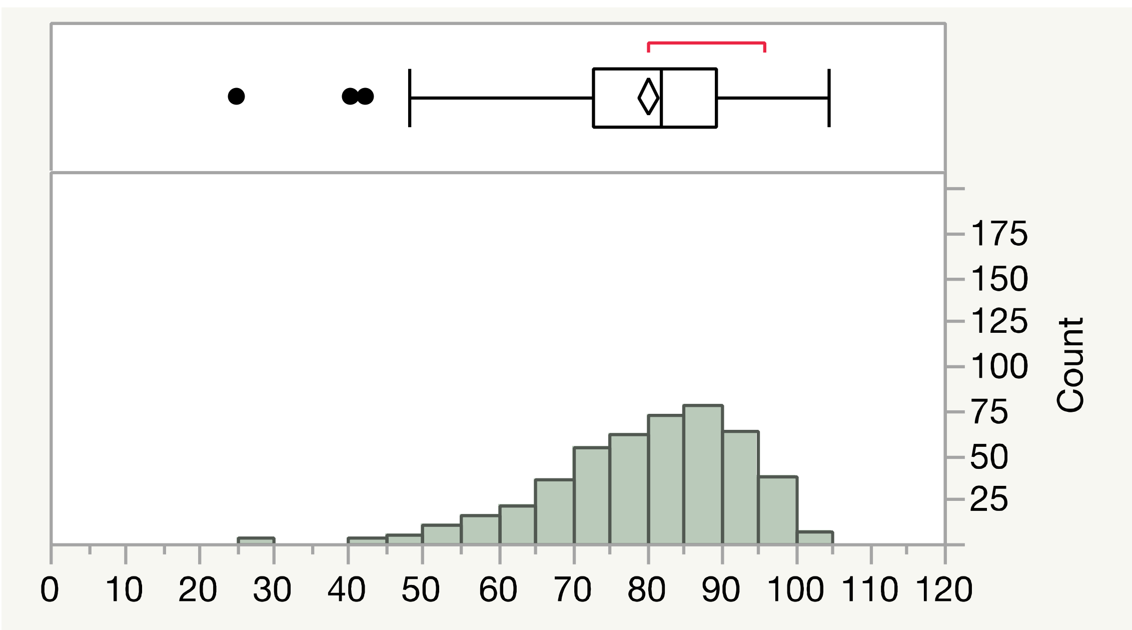

Figure 7: A&P I Fall 2012 Lab Score Distribution. Anatomy and Physiology I Fall 2012 semester lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 80.19 ± 0.57, with a standard deviation of 12.22. Students achieved higher than a 100 in some instances.

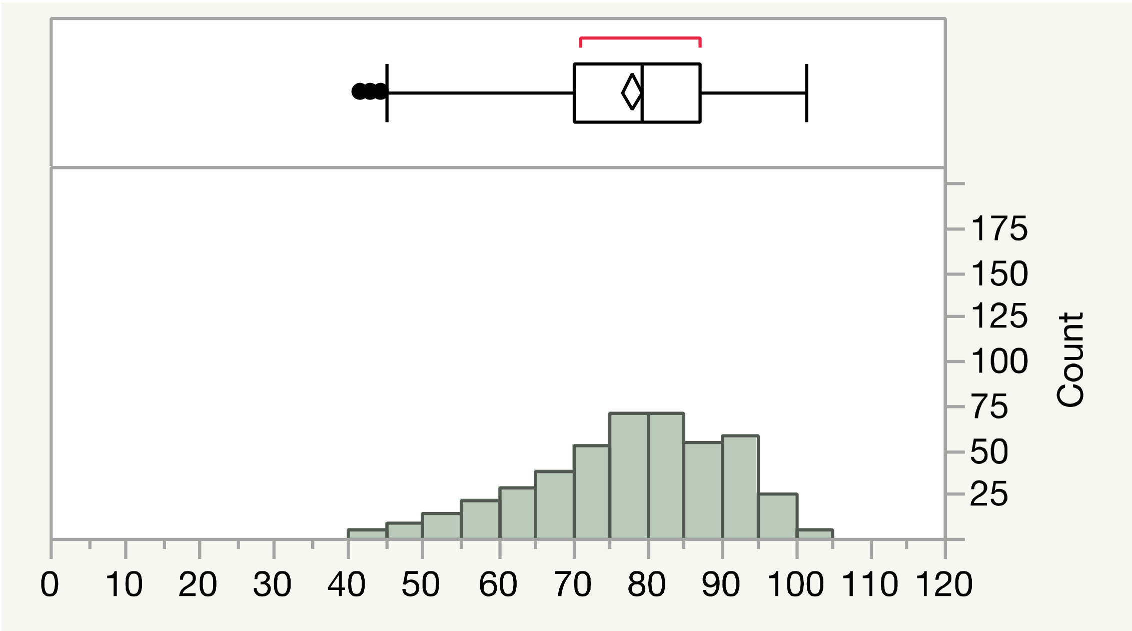

Figure 8: A&P I Spring 2013 Lab Score Distribution. Anatomy and Physiology I Spring 2013 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 77.89 ± 0.60, with a standard deviation of 12.52.Students scored higher than a 100 in some instances.

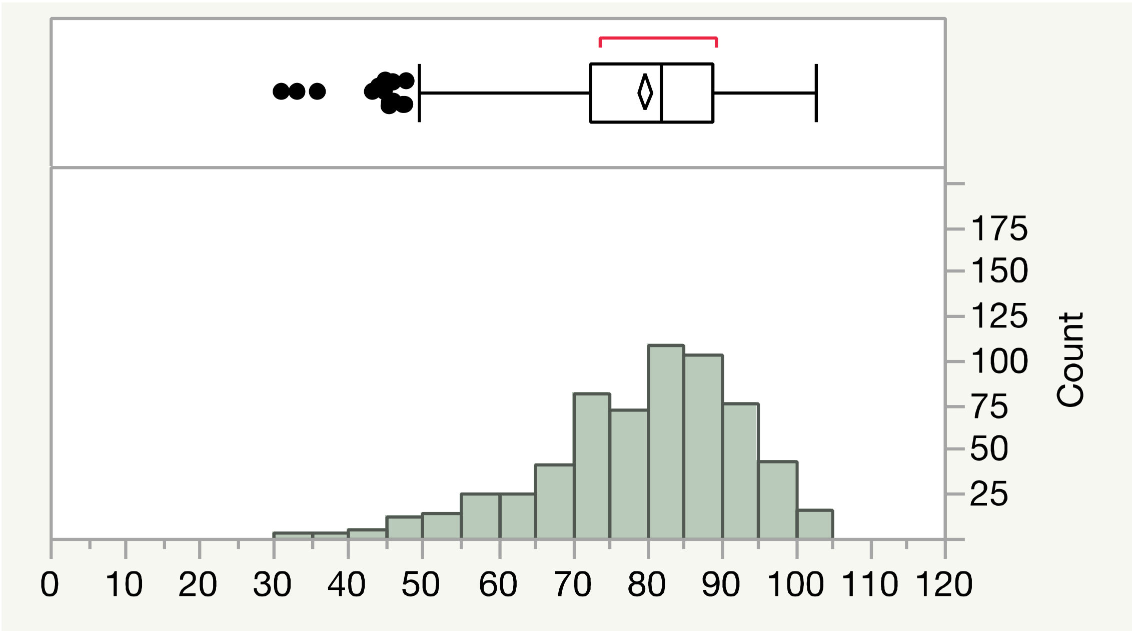

Figure 9: A&P I Fall 2013 Lab Score Distribution. Anatomy and Physiology I Fall 2013 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 79.67 ± 0.51, with a standard deviation of 12.76. Students scored higher than a 100 in some instances.

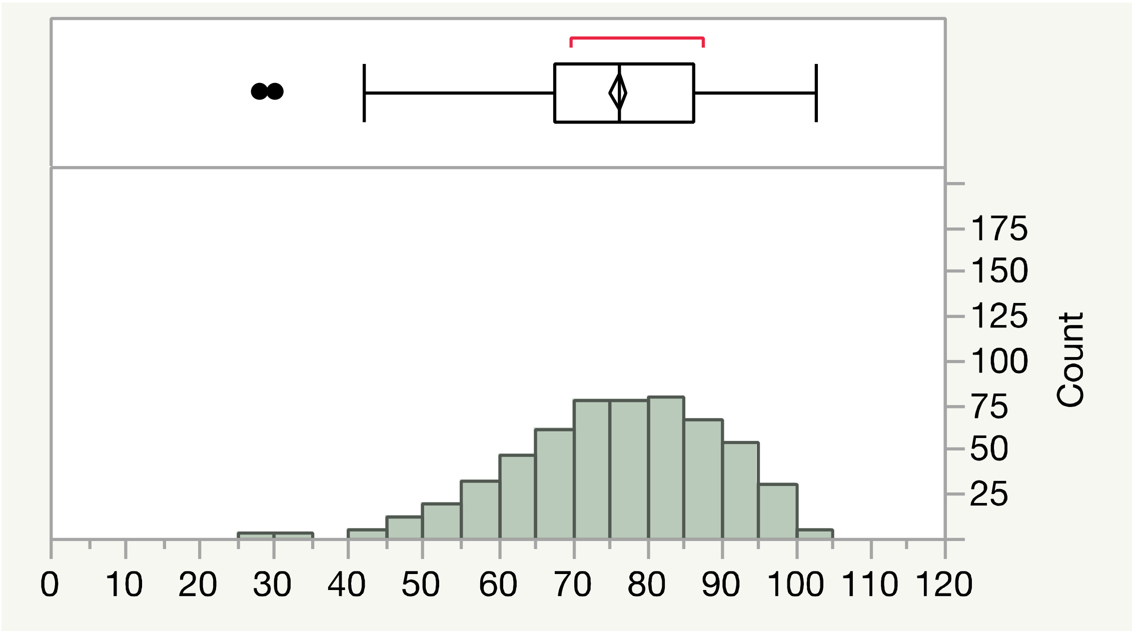

Figure 10: A&P I Spring 2014 Lab Score Distribution. Anatomy and Physiology I Spring 2014 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 76.03 ± 0.54, with a standard deviation of 12.82. Students scored higher than a 100 in some instances.

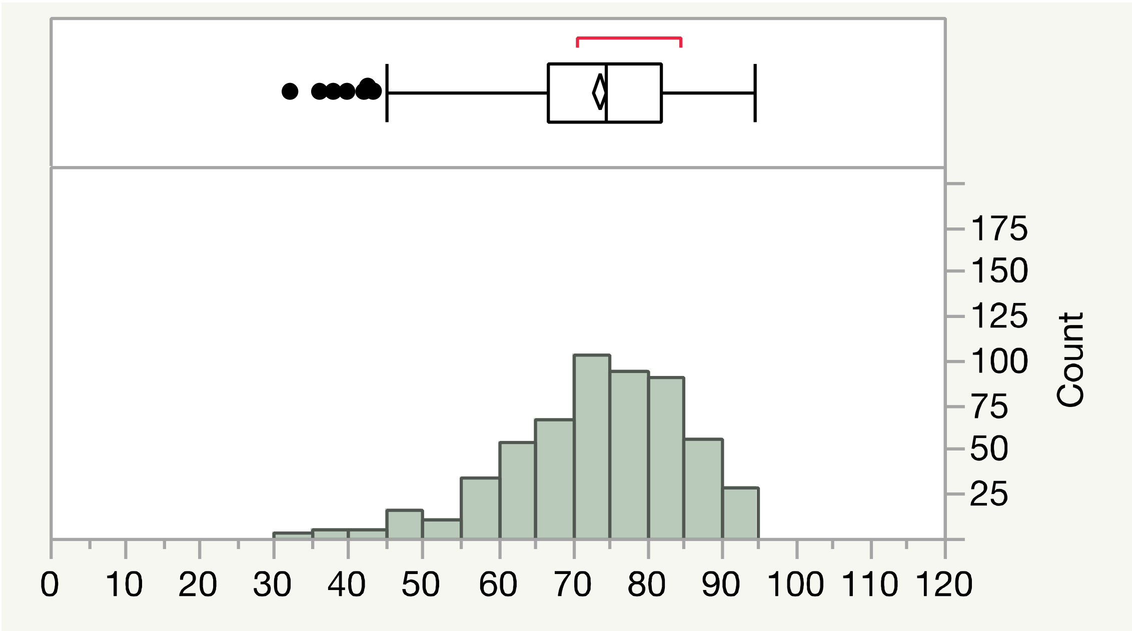

Figure 11: A&P I Spring 2015 Lab Score Distribution. Anatomy and Physiology I Spring 2015 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 73.53 ± 0.47, with a standard deviation of 11.11. No student scored above 100.

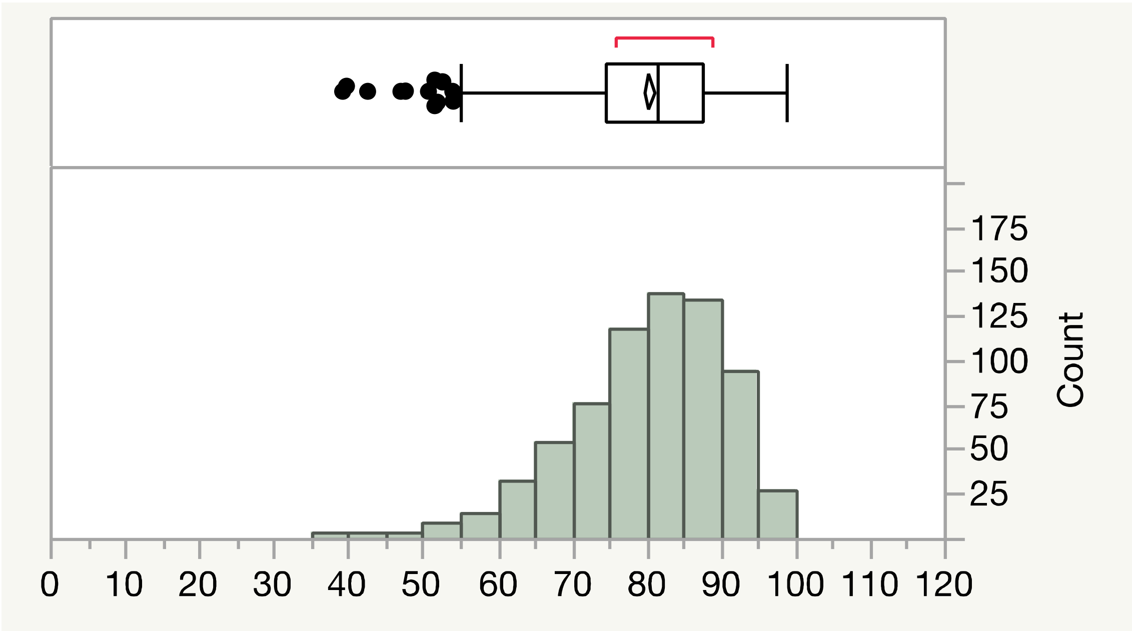

Figure 12: A&P I Fall 2015 Lab Score Distribution. Anatomy and Physiology I Fall 2015 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 80.26 ± 0.38, with a standard deviation of 10.11. No student scored above 100.

Lab grade histograms are used for Anatomy and Physiology II. The figures are once again split by semester, with the last two figures showing Spring and Fall 2015. For Anatomy and Physiology II, the extra credit inflation was much more pronounced, especially during Fall 2013. All traditionally taught labs averaged higher grades than their flipped model counterparts. Spring 2013 averaged 92.25 overall. For the flipped semesters, they average decreased to 81.79 for Spring 2015, and 78.93 for Fall 2015. These latter two semesters were much more in line with the grades seen for A&P I.

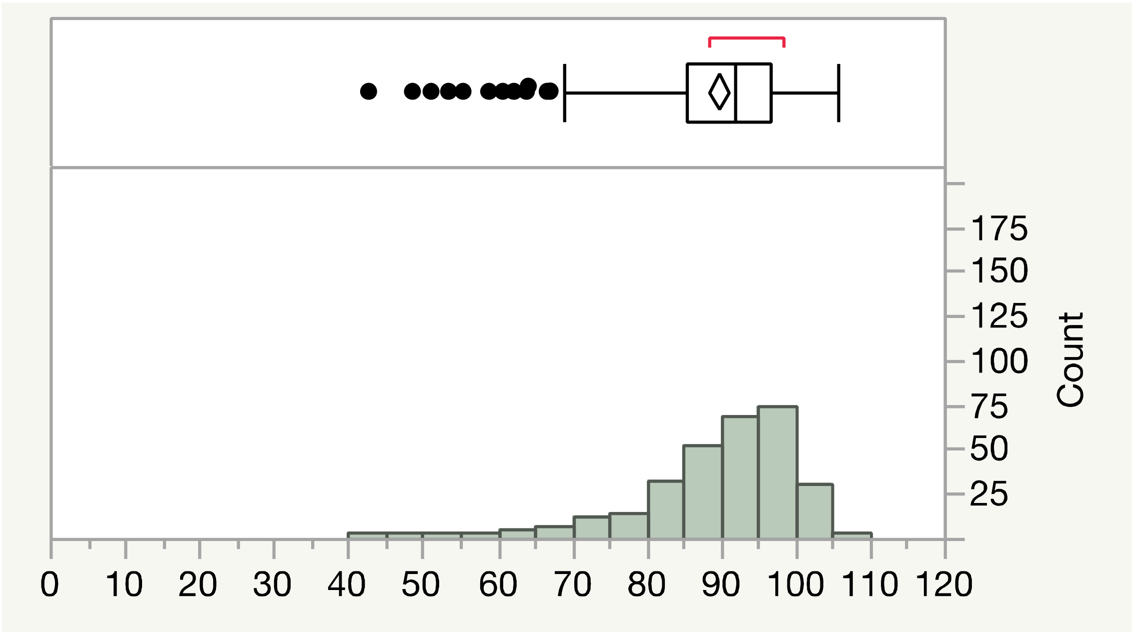

Figure 13: A&P II Fall 2012 Lab Score Distribution. Anatomy and Physiology II Fall 2012 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 89.64 ± 0.60, with a standard deviation of 10.24. Students scored higher than a 100 in some instances.

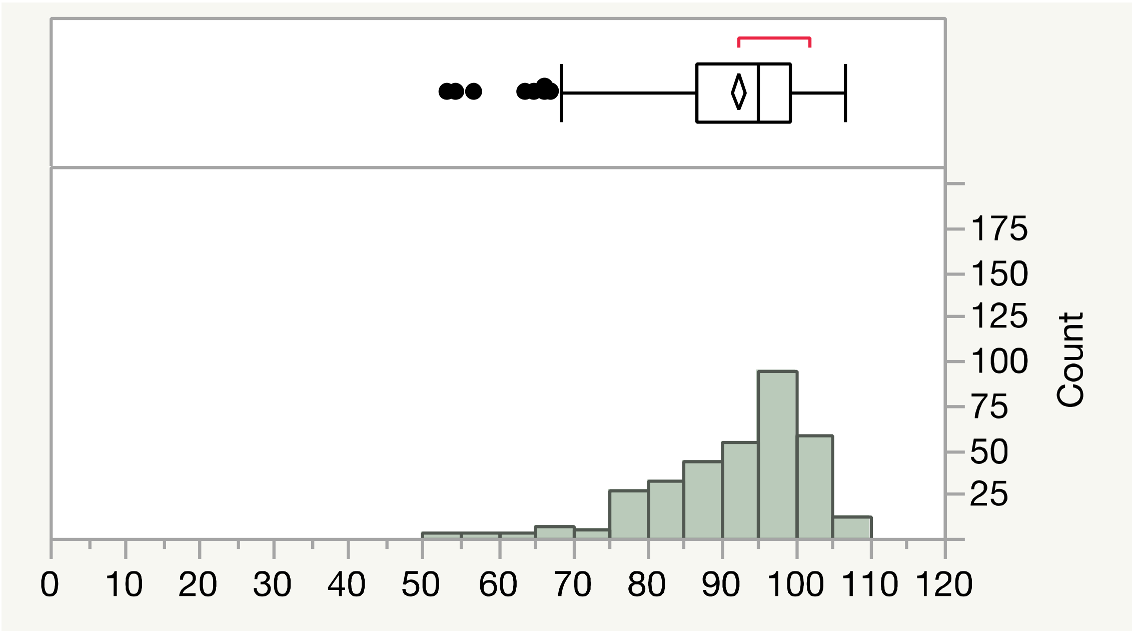

Figure 14: A&P II Spring 2013 Lab Score Distribution. Anatomy and Physiology II Spring 2013 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 92.25 ± 0.53, with a standard deviation of 9.65. Students scored higher than a 100 in some instances.

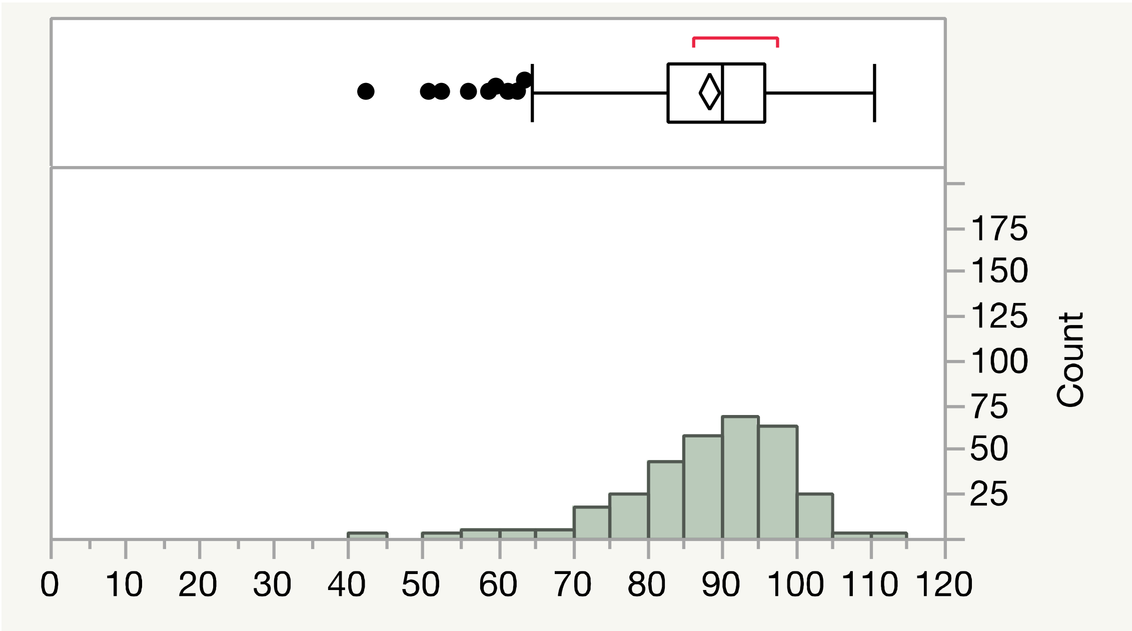

Figure 15: A&P II Fall 2013 Lab Score Distribution. Anatomy and Physiology II Fall 2013 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 88.37 ± 0.58, with a standard deviation of 10.19. Students scored higher than a 110 in some instances.

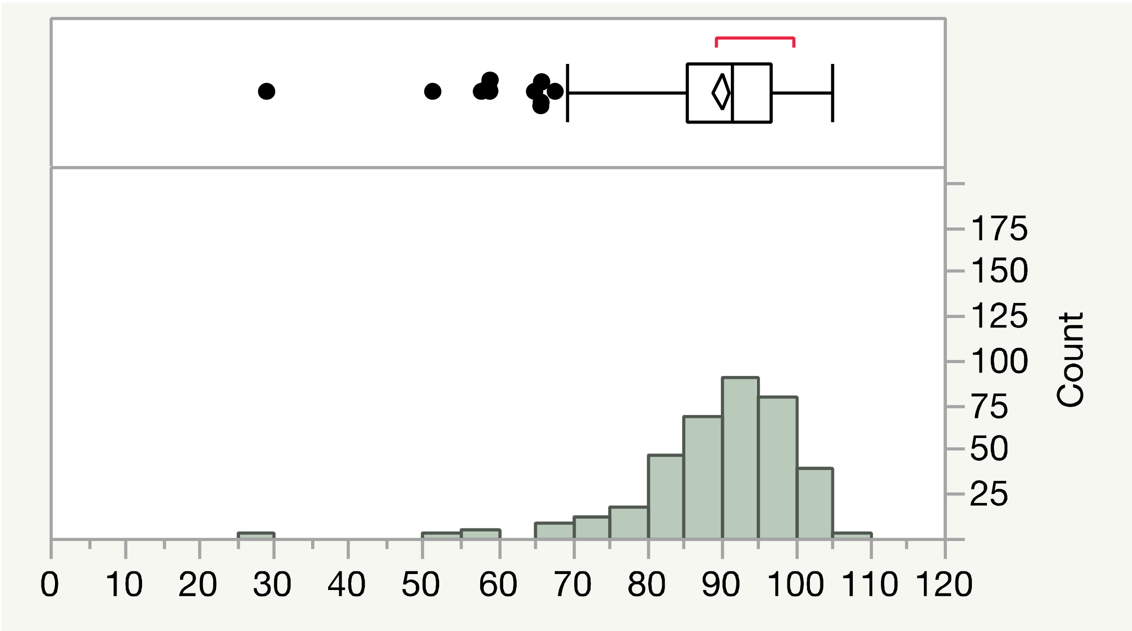

Figure 16: A&P II Spring 2014 Lab Score Distribution. Anatomy and Physiology II Spring 2014 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 89.98 ± 0.50, with a standard deviation of 9.55. Students scored higher than a 100 in some instances.

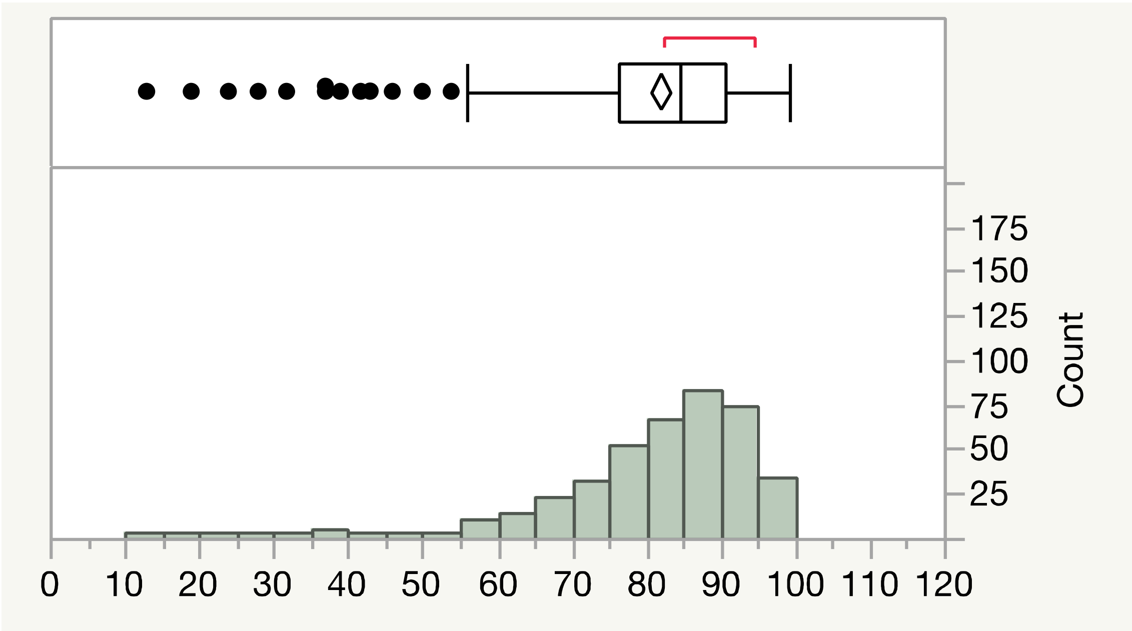

Figure 17: A&P II Spring 2015 Lab Score Distribution. Anatomy and Physiology II Spring 2015 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 81.79 ± 0.66, with a standard deviation of 13.06. No student scored above 100.

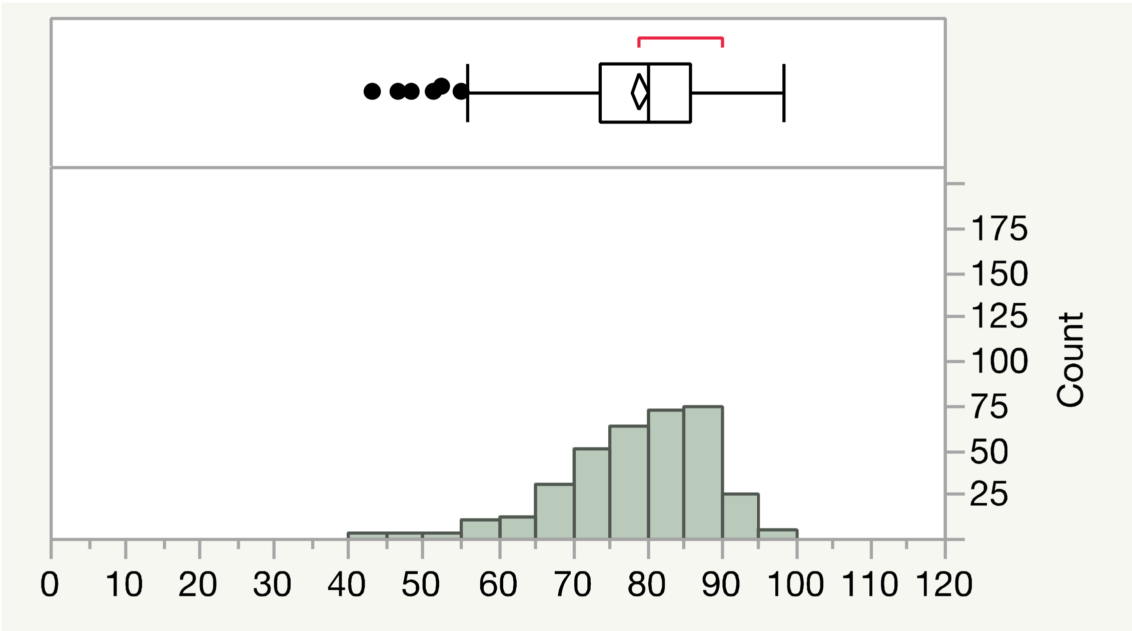

Figure 18: A&P II Fall 2015 Lab Score Distribution. Anatomy and Physiology II Fall 2015 lab histogram. Overall lab grade compiled to show grade distributions. Average lab grade was 78.93 ± 0.50, with a standard deviation of 9.31. No student scored above 100.

Overall Lecture Grade

Overall lecture grades distributions for Anatomy and Physiology I include the lab grade, which accounted for 33% of the overall course grade. The highest average course grades appeared in the last two recorded semesters (Figures 23 &24, 78.57 and 78.17 for Spring & Fall 2015) where the flipped model was implemented. Standard deviation and standard error of the mean varied from semester to semester, with no observable pattern once the flipped model was used.

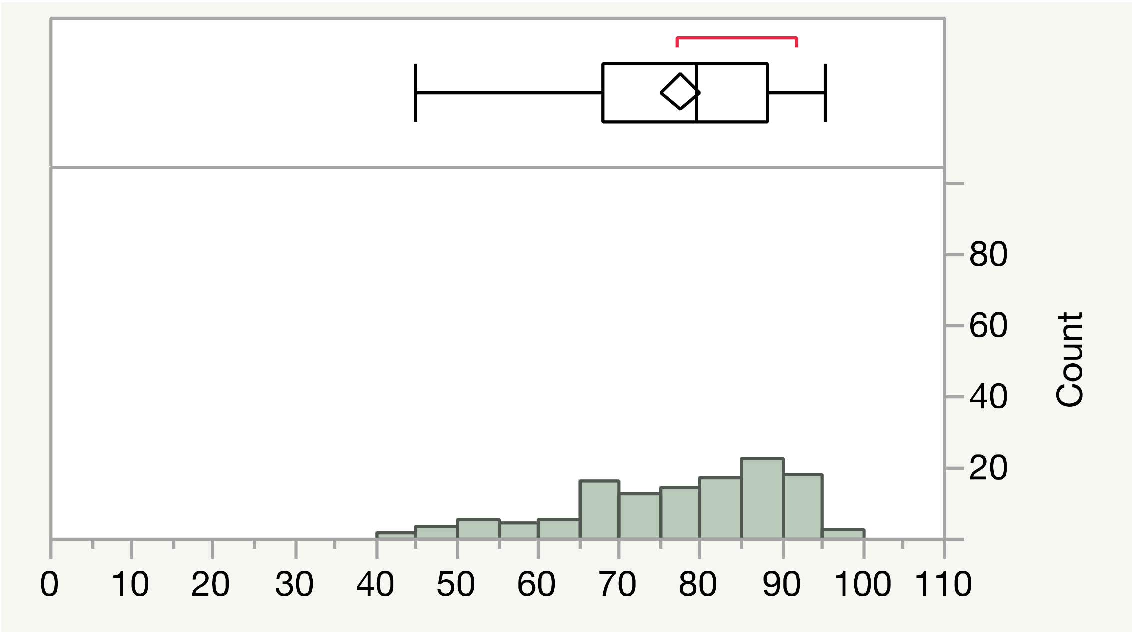

Figure 19: A&P I Spring 2013 Lecture Score Distribution. Anatomy and Physiology I Spring 2013 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 77.36 ± 1.16, with a standard deviation of 12.55. Students scored higher than a 100 in some instances.

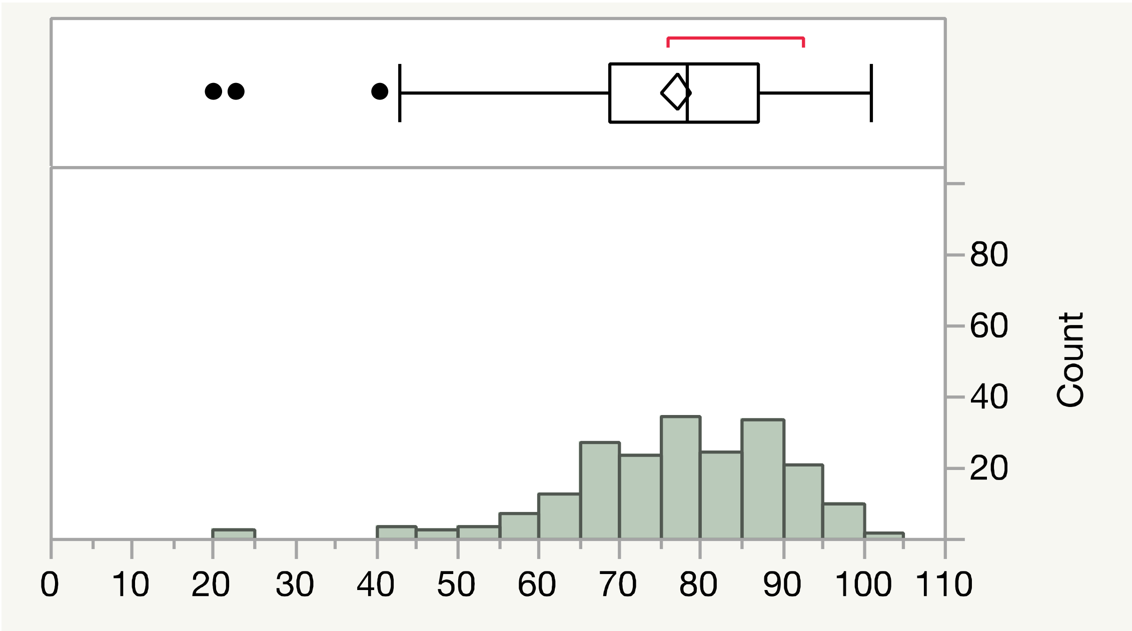

Figure 20: A&P I Fall 2013 Lecture Score Distribution. Anatomy and Physiology I Fall 2013 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 76.88 ± 0.93, with a standard deviation of 13.10. Students scored higher than a 100 in some instances.

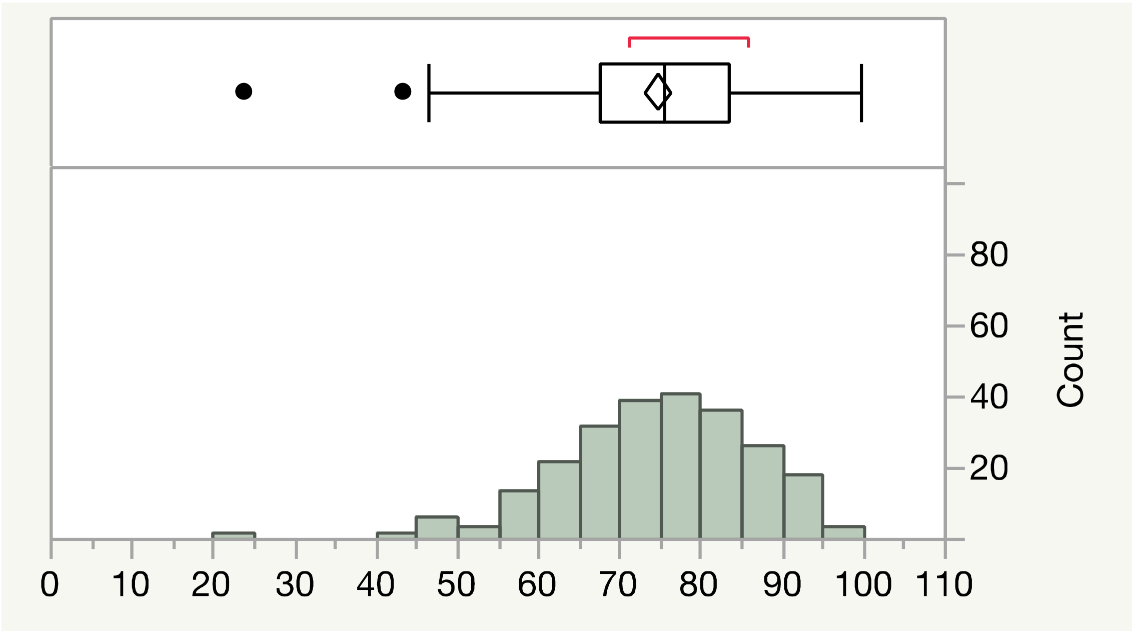

Figure 21: A&P I Spring 2014 Lecture Score Distribution. Anatomy and Physiology I Spring 2014 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 74.62 ± 0.76, with a standard deviation of 11.61. No student scored above 100.

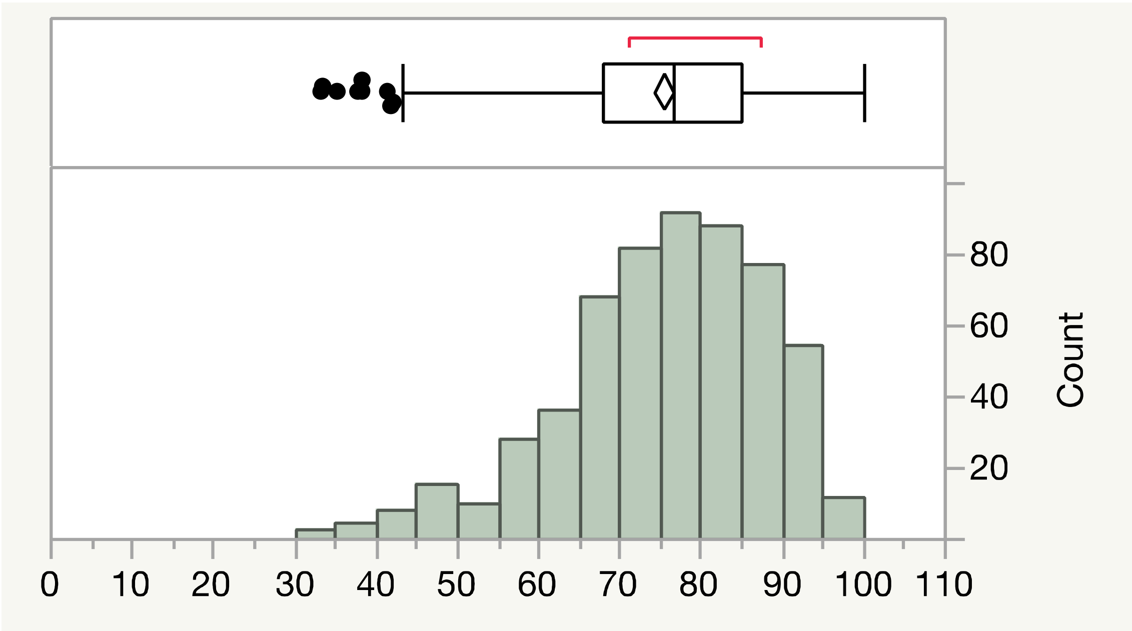

Figure 22: A&P I Fall 2014 Lecture Score Distribution. Anatomy and Physiology I Fall 2014 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 75.43 ± 0.52, with a standard deviation of 12.49. No student scored above 100.

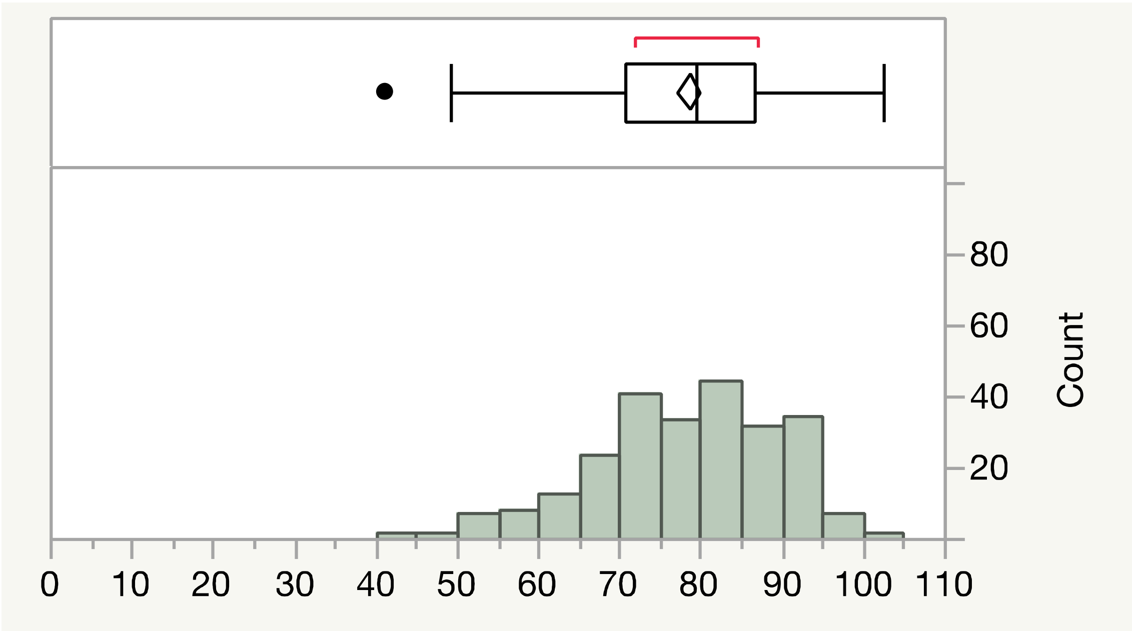

Figure 23: A&P I Spring 2015 Lecture Score Distribution. Anatomy and Physiology I Spring 2015 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 78.57 ± 0.71, with a standard deviation of 11.05. Students scored higher than a 100 in some instances.

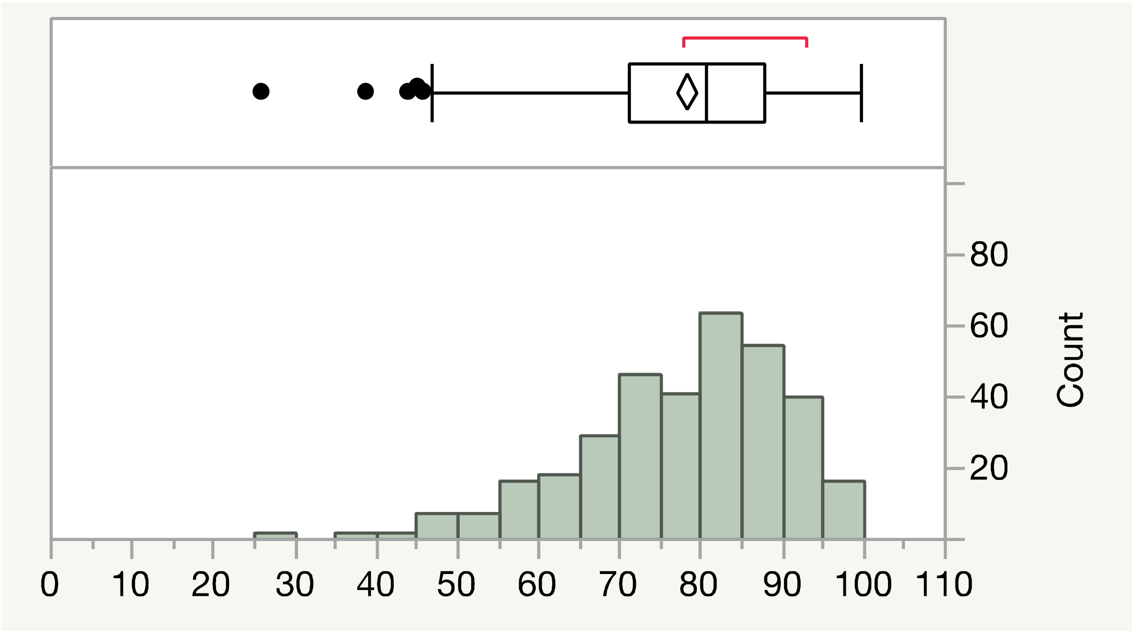

Figure 24: A&P I Fall 2015 Lecture Score Distribution. Anatomy and Physiology I Fall 2015 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 78.17 ± 0.67, with a standard deviation of 12.28. No student scored above 100.

Overall course grade distributions for Anatomy and Physiology II are shown in histograms. The highest recorded average course grades (81.16 and 78.18 for Spring and Fall 2015) again occurred in the last two semesters where the flipped model was used. Standard deviation and standard error of the mean also gave their lowest points during the flipped model semesters.

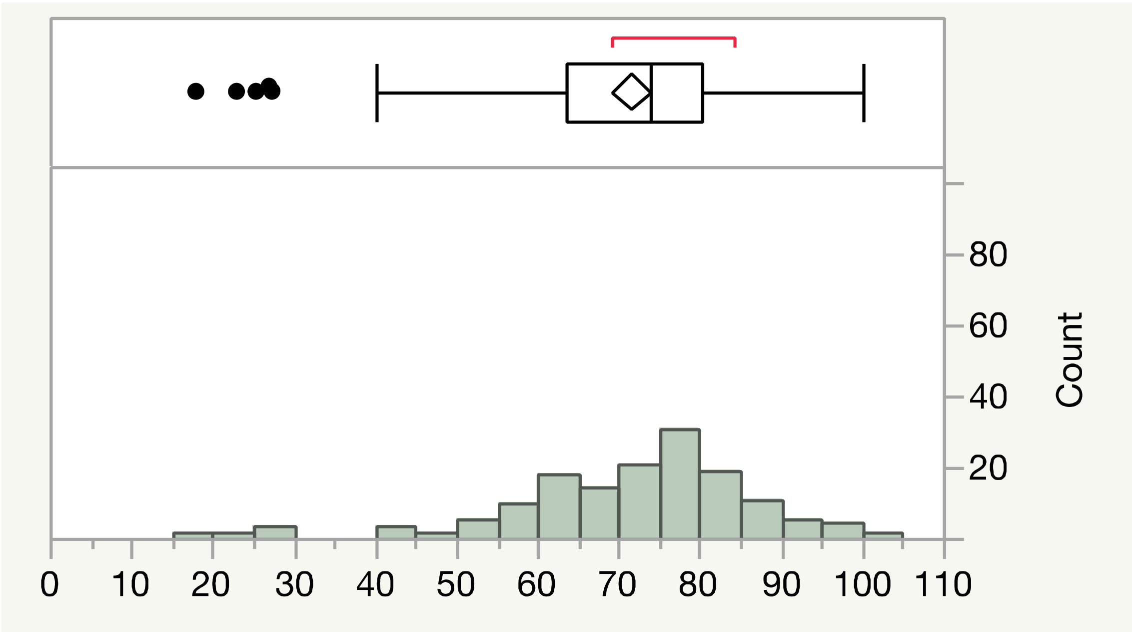

Figure 25: A&P II Fall 2012 Lecture Score Distribution. Anatomy and Physiology II Fall 2012 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 71.38 ± 1.24, with a standard deviation of 14.79. Students scored higher than a 100 in some instances.

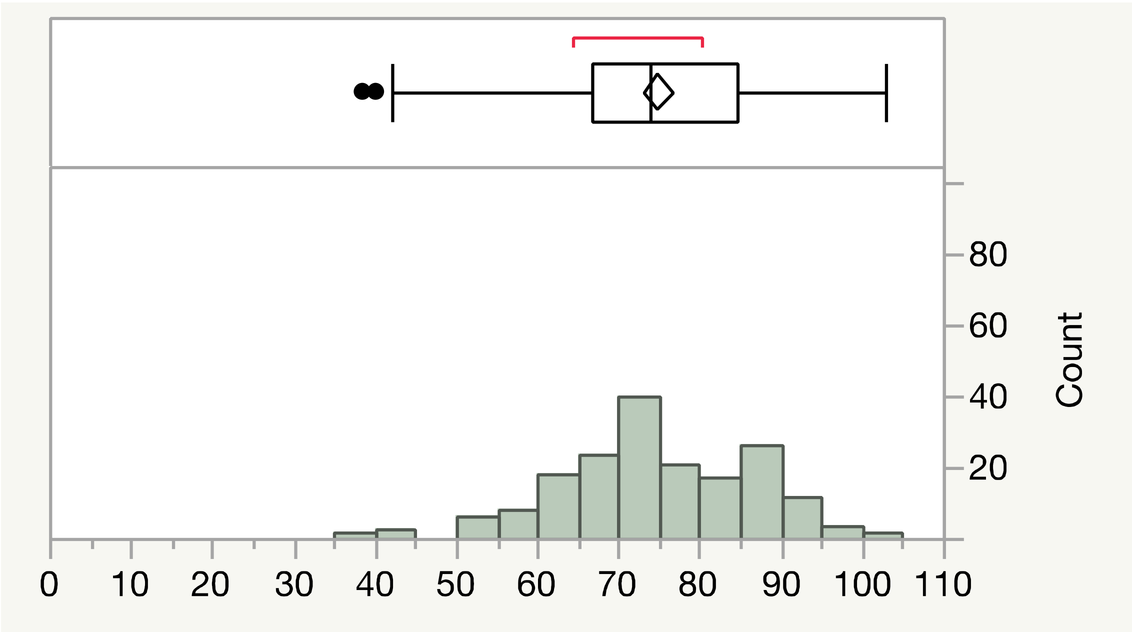

Figure 26: A&P II Fall 2013 Lecture Score Distribution. Anatomy and Physiology II Fall 2013 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 74.73 ± 0.90, with a standard deviation of 11.75. Students scored higher than a 100 in some instances.

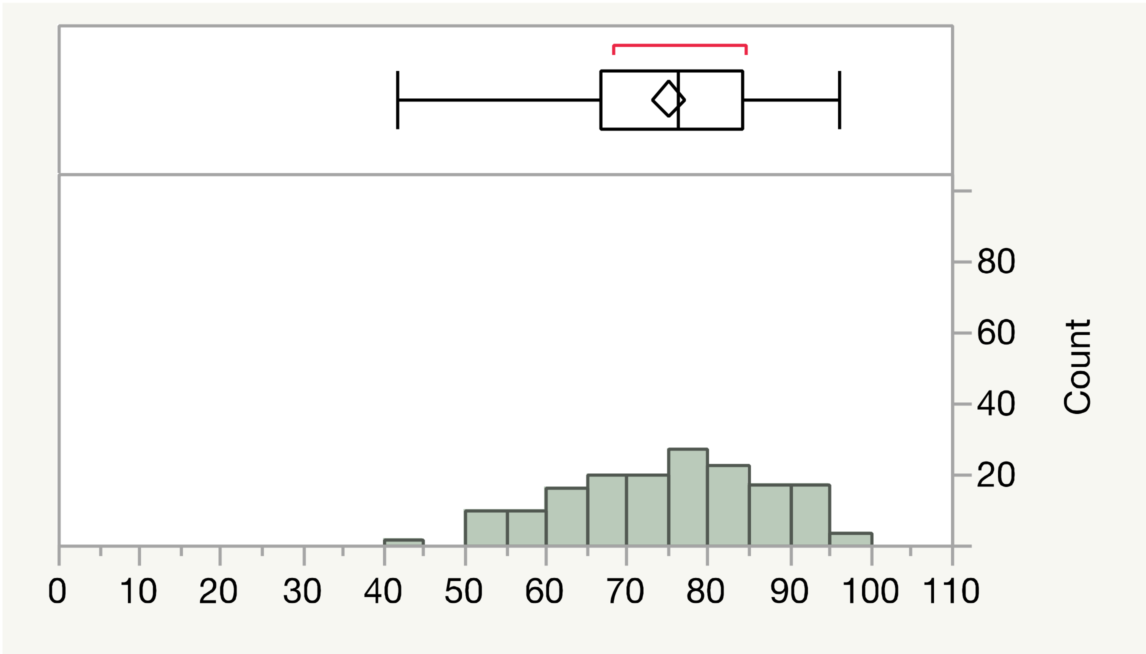

Figure 27: A&P II Spring 2014 Lecture Score Distribution. Anatomy and Physiology II Spring 2014 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 75.03 ± 0.96, with a standard deviation of 12.03. No student scored above 100.

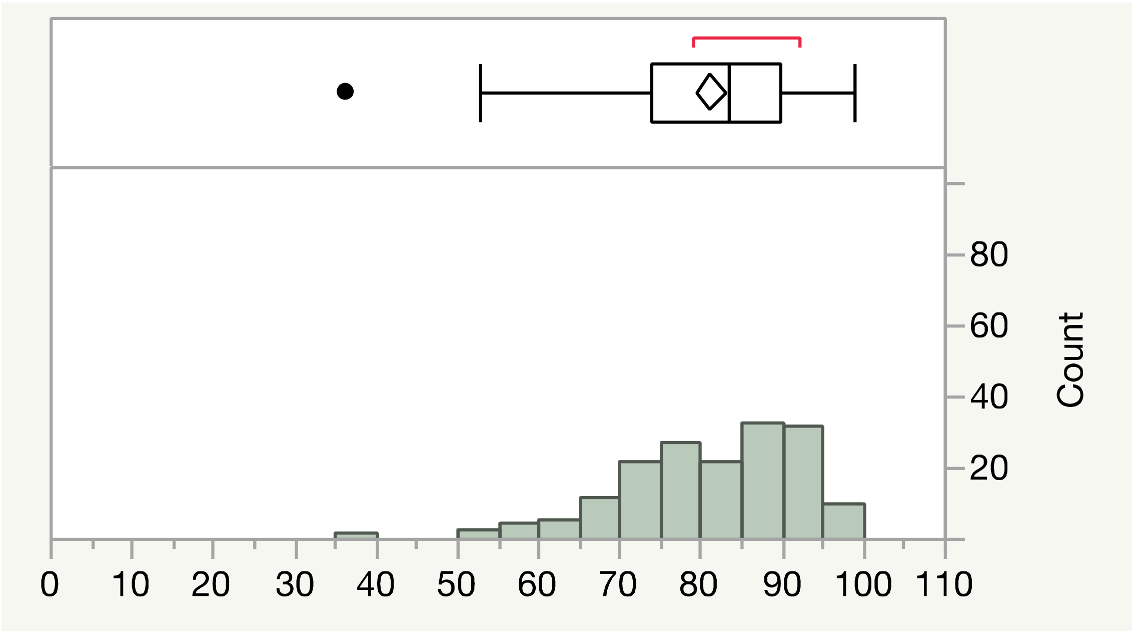

Figure 28:A&P II Spring 2015 Lecture Score Distribution. Anatomy and Physiology II Spring 2015 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 81.16 ± 0.83, with a standard deviation of 10.66. No student scored above 100.

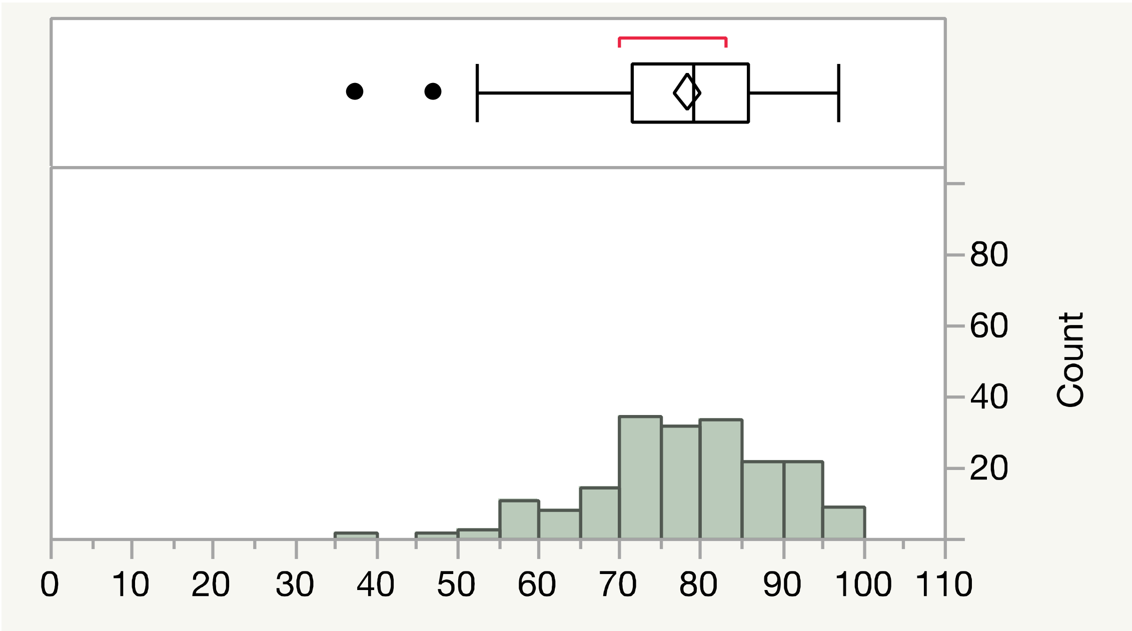

Figure 29: A&P II Fall 2015 Lecture Score Distribution. Anatomy and Physiology II Fall 2015 lecture histogram. Lecture grades compiled to show grade distributions. Average course grade was 78.18 ± 0.80, with a standard deviation of 10.92. No student scored above 100.

For all histograms, it is important to note that the class sizes varied between semesters, and year to year. Not all lectures and labs were recorded and compiled in every semester, as some faculty were unable to contribute their grade books to the data pool. As a result, descriptive statistics used for these figures may not accurately represent averages of the student population every semester. Despite the limitation, the data shows clear trends that students performed better overall in the flipped classes despite some course metrics decreasing (e.g., lab quizzes, exams).

Regression Analysis

Anatomy and Physiology I taught traditionally gave an r^2 value of 0.60 (Figure 30). The r^2 value dropped to 0.48 during the semesters when the flipped labs were used (Figure 31). The same pattern was observed for Anatomy and Physiology II, with the r^2 value at 0.569 (Figure 32) for traditional semesters and 0.564 (Figure 33) for the flipped semesters.

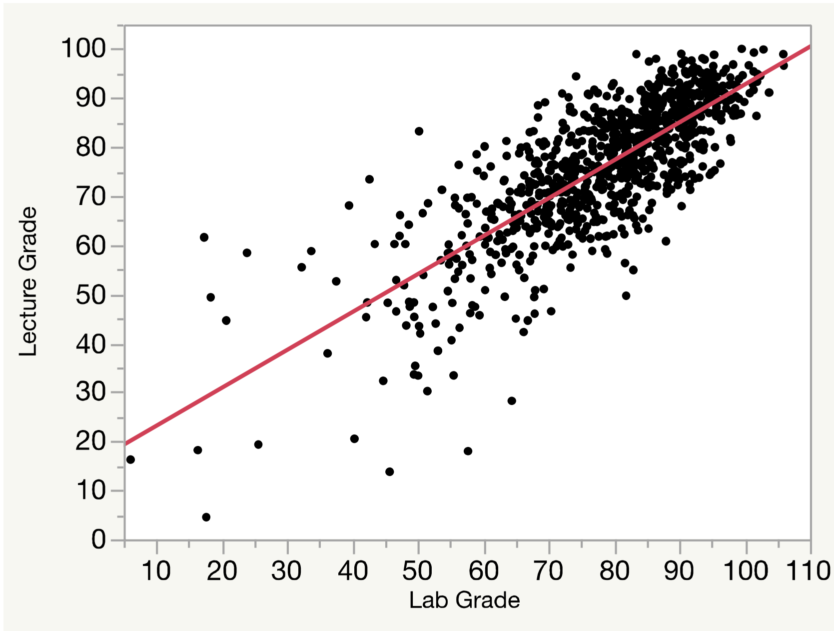

Figure 30: A&P I Regression Analysis (traditional). Regression analysis showing relationship between lab grades and lecture grades for Anatomy and Physiology I. Overall lab grades and course grades from traditional labs were compiled. R^2 value was 0.60.

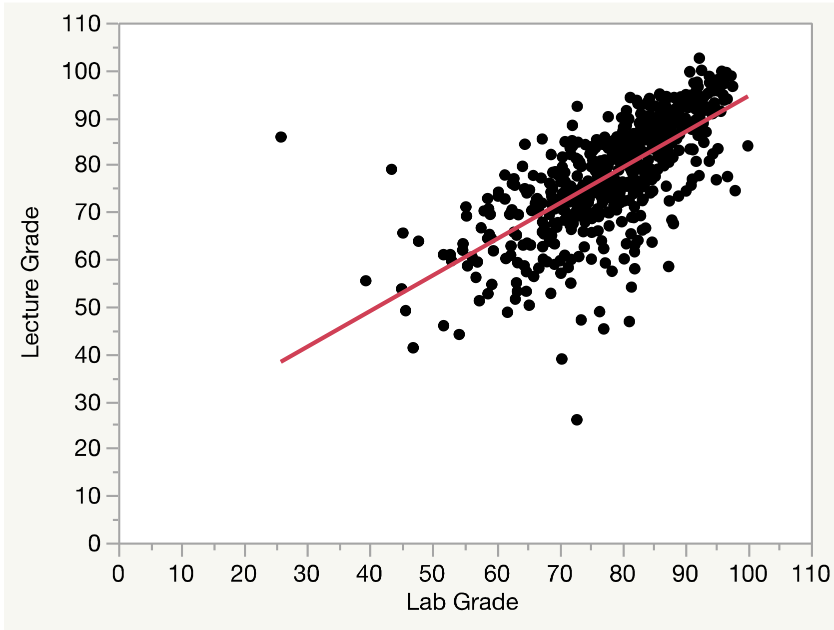

Figure 31: A&P I Regression Analysis (flipped). Regression analysis showing relationship between lab grades and lecture grades for Anatomy and Physiology I. Overall lab grades and course grades from flipped labs were compiled. R^2 value was 0.48.

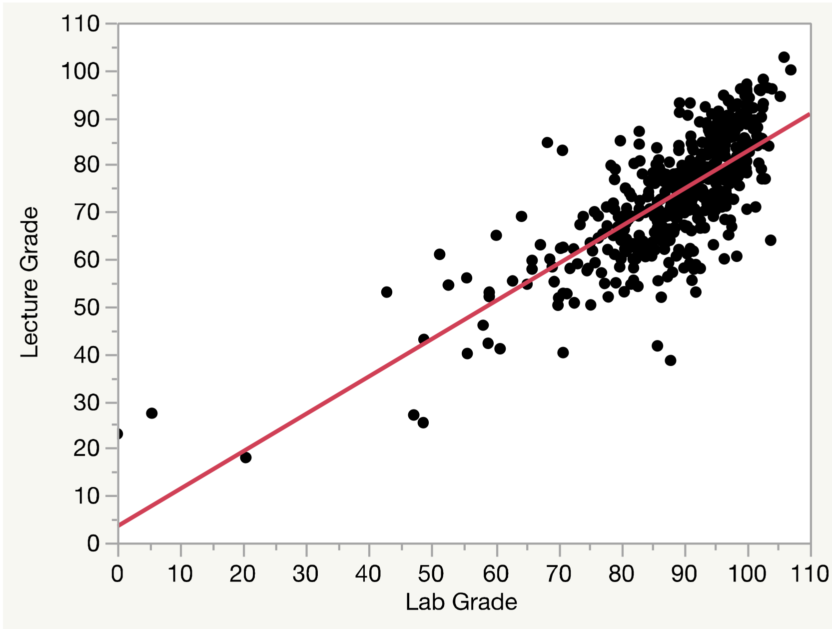

Figure 32: A&P II Regression Analysis (traditional). Regression analysis showing relationship between lab grades and lecture grades for Anatomy and Physiology II. Overall lab grades and course grades from traditional labs were compiled. R^2 value was 0.569.

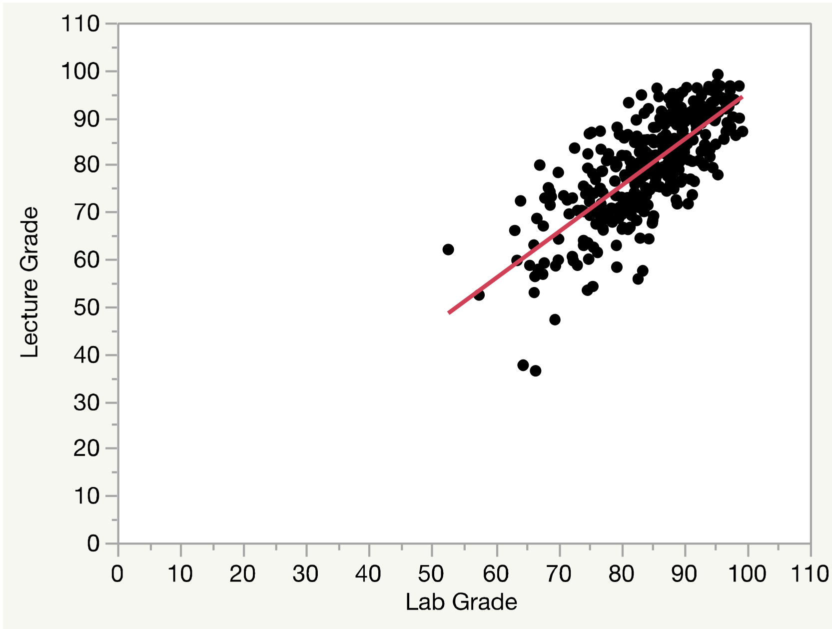

Figure 33: A&P II Regression Analysis (flipped). Regression analysis showing relationship between lab grades and lecture grades for Anatomy and Physiology II. Overall lab grades and course grades from flipped labs were compiled. R^2 value was 0.564.

Coefficient of determination attempts to predict the dependent variables from the independent variables, all plotted around the regression line. The r^2 values from both courses decreased as the flipped labs were implemented; there are several reasons why this may be the case. For example, data collected from the flipped classroom was not as numerous as data from the traditional classroom (only 2 flipped semesters). Fewer data points may have influenced the r^2.

Chi-square Analysis

Chi-square analyses were used on Anatomy and Physiology I and show that there was indeed a statistically significant change in grade distributions from traditional and flipped labs (i.e., the test statistic calculated from the data exceeds the critical $\chi 2$ value). The Chi-square test on Anatomy and Physiology II also gave similar results with statistically significant changes in grade distributions when flipped labs were used. More students received passing grades (B, C or D) while in the flipped model compared to the traditional model.

Table 7: Anatomy and Physiology I Lab Chi-square analysis

	A	**B**	**C**	**D**	**F**	**df**	**χ 2**	**Critical χ 2**	**P value**
Traditional % of students	20	30	26	14	10	4	71.94	9.488	$P<0.05$
Flipped # (expected) of students	246	370	321	173	123				
Flipped # (observed) of students	146	413	384	201	89				

Chi-square analysis on overall lab grades for Anatomy and Physiology I. Sample size for the traditional labs is larger than the sample size for flipped labs, so a percentage was determined for the traditional lab to normalize the comparison in grade distributions between the two styles of labs.

Table 8: Anatomy and Physiology II Lab Chi-square analysis

	A	B	C	D	F	df	χ 2	Critical χ 2	P value
Traditional % of students	58	28	10	2	2	4	681.32	9.488	P<0.05
Flipped # (expected) of students	420	202	72	15	15				
Flipped # (observed) of students	133	291	192	72	36				

Chi-square analysis on overall lab grades for Anatomy and Physiology II. Sample size for the traditional labs is larger than the sample size for flipped labs, so a percentage was determined for the traditional lab to normalize the comparison in grade distributions between the two styles of labs.

CHAPTER V

DISCUSSION

There were two overall aims to the study. The first was to determine the effects of the flipped classroom model on the Anatomy and Physiology laboratory courses at UTRGV. It was hypothesized that both formative and summative assessments scores would increase, as the flipped labs had an increased emphasis on active learning. The results showed that all assessments, both formative and summative, had decreased averages once the flipped model was used during the Spring 2015 semester and onward. ANOVA results showed that lab quizzes, midterms, and final exams differed to a significantly different degree from scores in traditional labs. This was unexpected, as prior literature doesn't corroborate the results found within the study. Most studies have shown that under the flipped model, student performance improves overall (Bhagat et al., 2016; Chen et al., 2014; Zhonggen & Guifang, 2015). Others show that the flipped lab made no statistically significant difference at all (Heyborne & Perrett, 2016; Morgan et al., 2015).

Nevertheless, it is important to note that there was several variables that could have artificially inflated the scores under the traditionally taught labs. For example, there were inconsistencies among the teaching assistants who taught the lab. The largest issue comes from the assessments that included substantial extra credit opportunities in the traditional labs compared to the flipped labs. This was even more pronounced in the second Anatomy and

Physiology course. Unfortunately, there was not a proper way to adjust for the grade inflation, thus, the results indicate that averages decreased. The second aim of the study shifted its focus to the lecture portion of the course in which grades did improve to a statistically significant degree. The lecture average data provided a much fairer comparison amongst the two styles of teaching, as the extra credit opportunities were much more controlled when given by lecturers and professors. Both courses also returned lower standard deviation and standard error values, indicating a reduced dispersion seen in grades. Grade distributions for both lectures and labs showed that with this reduced dispersion, a higher number of students passed the course. This was corroborated by the lab averages, where students maintained a high “C” average in the flipped format without the added benefit of extra credit.

Future iterations of this study will require more control to properly compare the efficiency of the flipped classroom model when used in laboratories. The major limitation here was the usage of data from prior years that had no control in how the labs were taught. As the flipped model was incorporated, there was increased involvement from the faculty towards the laboratory sections, which improved the labs and better complemented the lecture. Ideally, a better comparison would involve a traditional and a flipped laboratory taught simultaneously using the same teaching assistant for both sections. Both sections should also involve the same cohort of students, who take pretest and posttest assessments before and after each instructional unit (Bhagat et al., 2016; Memon et al., 2016). This will eliminate many variables, therefore, providing a true comparison amongst traditional and flipped classes.

The flipped classroom model shows promise based on the results of the study. One interesting effect shown in the data was the positive effect that the flipped model provided for accompanying lecture classes even though lectures remained untouched. The push for active learning provided by the flipped classroom model gave a noticeable improvement for lecture while providing a more fulfilling and engaging experience in lab. Students under the flipped model acknowledge the increased difficulty (Koo et al., 2016) but overall perceptions of flipped courses are also positive (Hajid et al., 2016). Together with the increased number of students who attain a passing grade, the flipped classroom model shows great efficiency and efficacy moving forward not only for the laboratory where it is implemented, but also for its corresponding lecture section.

Flipping classrooms and laboratories are not limited strictly to science related disciplines. The flipped classroom model has been applied to other disciplines such as Math, Business, Education, Languages, and the Arts (Bhagat et al., 2016; Prashar, 2015; Al Zahrani, 2015; Chen et al., 2014; Brownlow, 2016). This is a prime example of the flexibility of flipped classrooms, in that this style of teaching can be employed in all disciplines in higher learning. In the cases where flipped classrooms can combine with online learning, the results are still positive while providing even more flexibility for students enrolled in the course (Morgan et al., 2015; Gubbiyappa et al., 2016). Students are able to access lectures and work on them at their own pace. The workload is higher, but learning is improved as student preparation is increased prior to meeting in classrooms.

Online oriented classrooms provide the best of both worlds. The initial workload for instructors is increased while online lectures are created. However, the potential benefits are worth the investment. The majority of higher learning institutions provide online learning tools for students and faculty that can be used to integrate flipped learning into the classroom (Empson, 2014). The most popular system, Blackboard™, was used in this study alongside SoftChalk™. Alternatives that provide peer-to-peer learning with full content creation would suffice as well. For those interested in using the flipped classroom model, the tools necessary to carry it out, including the online component, may already be in place.

Using a flipped classroom model also aims to reduce seat times. By moving some sections of the laboratory online, the duration of a laboratory is decreased overall. Reduced seat time classes can allow for an increased number of class offerings that can allow for higher enrollment numbers for universities. Several studies have shown that reduced seat times can also have a positive effect on the class. One study involved reducing the seat time for a faculty development course, and used pre and posttests to compare the shortened version of the course to the normal length version (deNoyelles et al., 2012). Higher perceptions were given to the reduced seat version, due in large part to a better balance of support and autonomy thanks to the online component of the course (deNoyelles et al., 2012).

Another study used the reduced seat time, alongside the flipped classroom model, to a similar success. A large chemistry class was flipped and reduced in duration by 66% by moving didactic content online (Baepler et al., 2014). The flipped classroom was also moved from a lecture hall into an active learning classroom. An active learning classroom features modular tables, which allow for group work, as well as white boards and projection systems to share work amongst classmates (Baepler et al., 2014). Results showed that classes given under a reduced seat time with a flipped and active learning emphasis perform as well as, if not higher than, a traditional classroom in just one third of the time (Baepler et al., 2014).

The precedent for flipped classrooms has clearly been established. They can work in many disciplines and levels of education, and offer a high level of flexibility for students. Through this, student performance and perceptions of courses can improve. This study is unique, largely due to the demographics of the University of Texas Rio Grande Valley. UTRGV is a

Hispanic Serving Institution with a student body that is typically first generation college students from low-income households. In some cases, English is not the students' primary language. Females make up the majority of the University, with over 15,000 in the student body. Out of 28,000 students, over 24,000 are Hispanic. University of Texas Rio Grande Valley is a minority serving institution, and these demographics represent what the rest of the country may look like in the near future.

By 2050, the US census predicts that the United States will become a majority-minority country (Colby & Ortman, 2015). As a result, the demographics of the future may look very similar to the demographics seen in the Rio Grande Valley. A study of flipped classroom effectiveness has not been undertaken for undergraduate biology laboratories, or for the effectiveness of the flipped model for this demographic. These results indicate the great potential the flipped model has on laboratories taught at the university level with these types of students. Further research may demonstrate the efficacy of the flipped classroom model at institutions like UTRGV.

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BIOGRAPHICAL SKETCH

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