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Correlations Between Introductory Students’ Attitudes About Physics and Conceptual Understanding

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CORRELATIONS BETWEEN INTRODUCTORY STUDENTS' ATTITUDES ABOUT PHYSICS AND CONCEPTUAL UNDERSTANDING

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By

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Raym Alzahrani ENTITLED Correlations Between Introductory Students' Attitudes About Physics and Conceptual Understanding BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT

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The purpose of this study is to measure correlations between the students' incoming attitudes, beliefs and expectations about physics and their conceptual understanding. The study presents a profile of the attitudes and beliefs for Wright State University students who enrolled in calculus-based General Physics I courses during academic years 2014-2015 and 2015-2016. Students' initial and final attitudes, measured using the CLASS, are correlated with initial and final conceptual gain, measured using the Force Concept Inventory. Students' initial attitudes (Opre) was correlated with students' gain (FCIgain) in many sections. Correlations between students' final attitudes (Opost) and their conceptual understanding (FCIpost), reported in work at other universities, were not consistently seen here. However, a significant correlation between students' initial attitudes and their conceptual understanding shows in most of the sections.

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To my husband,

to my wonderful parents

to all my family and friends, for all of your love and support.

Chapter 1

Introduction

Physics is fundamental to all other scientific disciplines, but despite that, students have negative views—connecting physics to the real world, understanding the structure of physics knowledge and approaching problem solving—about physics. Consequently, there are long-standing and extensive support for using educational research to improve students' attitudes, views and understanding of physics. Many research findings indicate that student attitudes toward physics typically worsen over their first semester course. Many physics faculty are concerned about how the majority of their students are learning, especially through introductory courses, which are designed to provide context that helps for building a strong understanding for students' later study. Also, they are hoping their students can know how to think critically and scientifically. There is a combination of very important variables which substantially influence students' abilities to learn. Students' beliefs and attitudes about physics is one of the most important effects that is strongly associated with their achievements [Madsen et al., 2015]. Students enter courses with a set of different attitudes that form and shape their conceptual understanding. As a result, many studies have been conducted to develop students' expectations to be more expert-like views. Unfortunately, there are fewer results about how attitudes or attitude shifts are connected to conceptual gains.

1.1 Purpose of Study

As indicated before, there are few research studies that have tried to study the connection between students' attitudes and their conceptual learning. In this thesis, I will consider a number of possible attitudinal and conceptual correlations using data reported by a questionnaire administered to 891 students of General Physics I at Wright State University. The study investigates whether attitudes influence students' performance in General Physics I by using two main measures, the Colorado Learning Attitudes about Science Survey (CLASS) and the Force Concept Inventory (FCI). We investigate several possible correlations among pre-course and post-course scores and shifts and compare to previously published results.

1.2 Significance of Study

A recent meta-review of attitudinal studies [Madsen et al., 2015] highlights a few results for the question of how students' attitudes connect with their conceptual understanding, but also calls for more research in this area. I have results compiled over nine sections, which allow us to look for recurring trends.

Chapter 2

Literature Review and Research Questions

2.1 Physics Education Research

Physics Education Research has been a growing field in physics departments over the past few decades [McDermott and Redish, 1999]. Research on teaching and learning of physics has substantially improved physics instruction. Achieving this goal requires much systematic research that should be effective and reliable. Physics Education Research (PER) as a field depends on the research conducted by physicists who are engaging in the teaching system, which helps students meet expectations and assess the professor and his or her method of teaching [Beichner, 2009]. This chapter will begin with an overview of some studies in PER.

2.2 PER General

Research in physics education has covered many topics such as student conceptual understanding and epistemology. Studens beliefs about how physics knowledge formed in physics and how it developed are described as epistemological beliefs about physics Kortemeyer [2007]. Beichner [2009] wrote a review summarizing much of this history. He started with pointing out the definition of Physics Education Researchers and a brief history about their field in US, not to mention their importance in the education process. The main role they play is giving teachers ideas and results of their studies. This outcome helps teachers to understand and to know the problems and difficulties that students face when they try to grasp many physics concepts. Physics Education Researchers' jobs are not only limited to "managing the introductory courses" or "setting up labs". They include different things such as:

1. Publishing articles
2. Giving talks
3. Getting funding.

Physics Education Research was found in the United States and it goes back to Lawson, Karplus, Renner. Much of the later research of college-level in PER relies on Lillian McDermott study of students' struggles with physics concepts. Beichner's review article also mentions the two main ways of doing research in physics education. The first one is qualitative research where they interview students and ask them to do some tasks, and then start analyzing their answers. In this way of conducting a study, a few number of students will be examined and it is more accurate to understand a student's ways of thinking, although it takes a long time and it is hard to generalize the results for all physics students. On the other hand, there is quantitative research, which is usually a simple paper with multiple surveys that students answer on them. This kind of study can be done for many students and can be generalized. Yet, its resolution is not strong enough to distinguish small details, so both qualitative and quantitative studies are important. The work presented in this thesis is a quantitative study.

Moreover, the article mentions the main trends that physics education researchers cover, which include:

- Problem solving
- Epistemology
- Conceptual understanding
- Attitudes

Finally, it highlighted that the physics education research field is improving and having a strong effect on understanding how students learn physics Beichner [2009].

"Investigation of Student Understanding of The Concept Of The Velocity in one dimension" by Trowbridge and McDermott [1980] is a qualitative study of students' conceptual understanding of velocity, so it's an example of one of the investigations that filled a lot of the first couple decades of PER. This descriptive study conducted in 1980 at the University of Washington. Students were interviewed for around 20 to 30 minutes and asked to answer some written motion tasks. The most important task was to observe rolling balls on pairs of paths. Students who participated in this investigation were enrolled in introductory courses and divided into the following groups:

- Calculus physics students (CP)

- Academically disadvantaged students (AD)
- Noncalculus general physics students from self-paced course (GPL)
- Noncalculus general physics students from lecture course (GLS)
- In-service elementary school teachers (IT)

The study found out around one-fifth of the students confused between the concepts of position and velocity. Students were unable to distinguish between different but related physics concepts such as: speed and position.

2.2.1 Measuring Conceptual Understanding

The Force Concept Inventory (FCI) tests students' understanding by using commonsense alternative or misconceptions of Newtonian concepts[Hestenes et al., 1992]. The FCI provides the education researchers with clear data that helps them with diving into inaccurate commonsense problems that students face with introductory physics courses. The article discusses this instrument for measuring students' conceptual understanding of Newtonian concepts, how we can use it and the results that they found. It is one of the most common tests available for measuring students' conceptual understanding, since Newtonian concepts are fundamental and all other mechanics rely on them. Students were asked to answer multiple-choice questions related to six conceptual dimensions such as: kinematics, impetus and active force. The questions are very ordinary and easy for students who understand physics, as many professors indicate. However, students performed poorly on them. The data showed a positive increase in students' scores on the inventory by the end of the semester. It also helps with understanding students' thinking of Newtonian concepts, which clearly can be a way of increasing the effectiveness of physics instruction. Finally, the study states that these misconceptions that many students have may stay with them for a long time unless we deal with them early and with more acculturation, so students can succeed Hestenes et al. [1992].

Hake [1998] collected different previous results that used Force Concept Inventory (FCI), Halloun & Hestenes Mechanics Diagnostic test (MD) and the problem-solving Mechanics Baseline (MB) test. The main purpose of gathering these data is comparing traditional lecture courses to courses with interactive engagement (IE) methods. Hake measured the impact of each method on the students' average normalized gain, which is the ratio of the actual average gain to the maximum possible average gain.

To make it clear to see the differences between those two methods, Hake divided the average normalized gain $< g >$ to three levels: high level: with $g > 0.7$, medium level with $0.7 > g > 0.3$, and low level with $g < 0.3$. The survey found that traditional courses' average gain reached +0.23 whereas IE courses achieved + 0.48 average gain. This result showed that courses with IE strategies increase the course's effectiveness as measured by on the conceptual and FCI test.

2.3 Research on Student Attitudes

Increasing scientific literacy for citizens is very important, especially among the university student population, which is one of the most important and essential groups that can lead to success in modern society. For this reason, there is an abundance of research that focuses on students' attitudes toward science courses, since those attitudes are critical to academic success. As a matter of fact, research evidence is very obvious in this issue. In this section we include summaries for some of these studies, as well as the most common and important surveys used to measure attitudes in physics.

The importance of studying students' attitudes towards science has been a major object over the last 30-40 years and still ongoing [Osborne et al., 2003]. Unfortunately, all research that studies this considerable issue suggest that there is constant decline not only in the students' attitudes towards studying science, but also in the number of students who chose to pursue studying science. This long term decline in the interest of science affects and threatens any society's economy. There are some affective behaviors on science education that have to be considered such as:

- The enjoyment of science learning experiences
- The adoption of 'scientific attitudes'
- The manifestation of favorable attitudes towards science and scientists

Another important point in science education research is to distinguish between studying students' attitudes towards studying science, which include students' feelings and beliefs about science in general, and "scientific attitude," which includes the interest of studying and having knowledge, respecting logic and searching in data for their meaning. In fact, one of the difficulties that faces science education research is the decline in students' attitudes towards studying science may vary from one student to another or even from one school to another. Above all, there are many factors that contribute in this variation. According to many studies there are many elements incorporated when they measure students' attitudes, for instance:

- Self-esteem at science
- Enjoyment of science
- Motivation towards science

- Fear of failure in course
- The perception of the science teacher

As a consequence, there are many research methods for measuring students' attitudes, which focus on multiple objects like what factor can impact that attitude, how they measured and what results they found.Basically, this kind of research relies on asking students to rank their school subject starting from their favorite one to least favorite one. These proportion results give a general perception about students' attitudes. In these findings, physics and chemistry were the least two favorable subjects for students. Also, later studies showed boys had more interest in science compared to girls, due to the fact of girls' perception their performance in other subjects is better than science.

Scaling students' attitude depends on giving students many statements that they have to answer using the Likert scale, a five-point scale would offer choices such as strongly agree, agree, not sure, disagree, strongly disagree. As reported by research there are many factors that affect students' attitudes, such as: gender, curriculum variables and classroom/teacher factors. In conclusion, students' attitudes towards studying science is an important topic that research has been studying because of its impact on both students and society. However, there is no solution yet for this problem [Osborne et al., 2003]

Moreover [Gardner, 1995] paper indicates the importance of having associated components in any psychometric study. Namely, rating attitude usually consists of many elements that are first measured separately then the sum of these scores gives a grand total score. Gardner gave a brief explanation of using scaling methods with many common items and how it measured. Moreover he clarifies the importance of having more than one item when measuring students' attitudes for more reliability. The most important thing is that these items must have a common construct that makes them correlate to each other. Otherwise, adding different scores that have nothing to do with each other will make confusion. This theoretical confusion might happen by adding items without justification, which produces unreliable scores. Another mistake that might happen is missing definition for any variable that is included in the measurement which will break the requirement of only having one construct. Finally, the research ends by giving a good example of a complete and proper psychometric study which is a good example for other research [Gardner, 1995].

Elby also in his study "Getting started with research on epistemologies and expectations" discusses epistemology and expectations the students have and defines expectations as students' views and beliefs about what they already know and what they are ready to learn in physics[Elby, 2010]. One important aim of physics education is to develop more expert-like views of physics and physics learning in students. As a result, physics education researchers are trying to understand and explain the difficulties that students face when they take physics courses. The paper shows that epistemology and expectations research depends on different areas. The formulas and concepts are the first area. In this paper researchers distinguish between two ways students view formulas. The first group views physics formulas as ways of solving problems and understanding which equation to use for that problem. On the other hand, there are students who see these formulas as ways to explain and describe natural phenomena. The second area of epistemology is whether students see these concepts coherently or in pieces. Students who understand these concepts coherently will be able to connect them to other equations. However, students who see these equations as pieces will not be able to relate them to each other. Another area relates to students' expectations; some students think that learning comes from building their knowledge by themselves, others believe it comes from textbooks and professor's instructions (the MPEX "Independence" dimension, see below). The last important area of research is knowing that there is interaction between student's epistemology and how much effort and work they put in. Furthermore, some students see the ability to understand and to apply physics as inherent rather than something that can be learned and improved. This view may affect, and reduce the level of effort they are willing to put into understanding physics. The paper also highlighted the different ways of studying epistemology and expectations, which includes conducting surveys and interviews. In conclusion, this article focuses on epistemology and expectation as an essential subject of many studies in the education research field. This kind of research not only helps with understanding and developing students' ways of learning physics, but also will help professors to develop their methods of teaching[Elby, 2010].

2.3.1 Maryland Physics Expectations Survey

The Maryland Physics Expectations survey (MPEX) [Redish et al., 1998] is an instrument to measure students' attitudes toward physics, and was developed using a population ranging from strong introductory students through university physics faculty. The survey studies students' behavior at the beginning and the end of the semester in six different institutions. First of all, the survey constructs 34 different statements, that covered six main clusters:

1. Independence: one of the most lofty goal that science students should obtain and aspire through their study process is to be able to construct new knowledge for themselves. This allows students to build their knowledge by themselves, rather than take it as given from teacher and materials.

2. Coherence: this cluster tests whether students see knowledge in physics as one connected, consistent framework, or they see them as pieces that are not connected to each other.

3. Concepts: This cluster is kind of about whether students can not only do textbook-style problems (many of them can), but also whether they can reason about the underlying concepts. So we are trying to distinguish whether they are just memorizing an algorithm, or can also connect it to bigger ideas.

4. Reality Link: which gives students ability to conect the ideas learned in physics to their lives.

5. Math Link: students should understand that mathematics is a tool that helps them to understand nature and physical phenomena.

6. Effort: making more effort on studying physics is required for all students.

Then, the study set up five calibration groups of experts and asked them these statements. The answers were given on a Likert scale, starting with strongly disagree and moving to strongly agree with the given statements. The next step was comparing the students' answers with the ideal answers from experts. Based on students' answers, the survey found that there were differences between the students' initial state and the calibration groups in all institutions. Furthermore, students' beliefs and understanding of physics classes often deteriorated by the end of the semester. Most of the students showed a binary way of thinking, where student tended to think of the physics concepts and problems as facts that have to be true or false without working on them by themselves and using their own personal experiences.

In general, this paper showed that the reality and what is going inside classrooms is totally different from what experts try to get. Experts and scientists try to present physics in a useful way, so that students can see how the information connects to each other and connects to real life. However, students' answers showed that during the semester the most important thing is to pass the class, by memorizing equations without understanding and restricting to the given information in the lecture and the textbook.

2.3.2 The Colorado Learning Attitudes about Science Survey

The Colorado Learning Attitude about Science Survey (CLASS) is a newer instrument that measures students' beliefs about physics courses and learning physicsAdams et al. [2006]. The survey was developed using previous surveys, including the MPEX, and contains 42 statements including some taken from the students themselves. This survey was applied in physics courses, but can be adapted to use in other science courses since it is more general [1] .

The first set of CLASS statements were validated using interviews started by asking students general questions about their courses, habit of study and attendance. Then the students answered the 42 statements that were concise and clear. According to students' responses, specialists analyzed these answers and put the similar statements under one category. This lead to 8 categories, including personal interest and real word connections.

After scoring students' answers (per percentage) and comparing them with the experts' answers they found that there are some factors that have to be taken into account when we are measuring students' attitudes. These factors include gender, the time spent in college and the student's age. To see whether students' answers were based on their situation or what they accepted they were expected to answer, the survey also asked them what they believed about physics by the end of the semester and found that students were good at identifying what were experts' responses, however their personal beliefs scored less. The survey indicated that students who are younger tended to scored higher on the 3 problem solving categories, whereas students who are older score higher in the statements that relate to connection to real world and personal interest categories. In addition,

[1] http://www.colorado.edu/sei/class/

the survey found that women in most of the represented statements scored lower than men. The larger research project of this CLASS is trying to increase the number of students who attend science, math and technology class, although the data showed decrease in this number[Adams et al., 2006].

"Evaluation of Colorado Learning Attitudes about Science Survey" by K.A. Douglass, M.S. Yale, D.E. Bennett, M.P. Haugan and L. A. Bryan, published in 2014 by the American Physical Society evaluates this widely-used tool to measure student attitudes toward physics and learning physics by examining its psychometric properties[Douglas et al., 2014]. They argue that there are problems with evaluating curriculum reform of physics education using the Colorado Learning Attitudes about Science Survey (CLASS) because of its level of complexity as well as its use of several items to score more than one factor. They believe a simpler model may be more appropriate. The researchers administered an online CLASS survey to students in an introductory calculus-based physics course at a Midwestern university. Before administering the survey, researchers identified which questions on the CLASS survey measured more than one item and should probably be deleted. They used exploratory factor analysis to determine a simpler conceptual understanding of the data by identifying which items correlated with each other, and they created a more parsimonious version of the survey. Then, the results of the full CLASS survey were compared to the simpler one.

The results of the data analysis indicate that both surveys yielded the same results. Although there is a loss of some item-level data, researchers can more easily interpret and understand student attitudes. The analysis found that the three subsections of the reduced survey— Personal Application and Relation to the World, Problem Solving and Learning, and Personal Effort and Sense Making— correlate significantly and have a high level of reliability. This helps to understand a general attitude towards physics by students.

2.3.3 Recent Results on Student Attitudes in Physics

As explained above, many education studies focus on the student's attitudes toward physics courses and its importance of developing students' understanding of physics. The "Extending positive CLASS results across multiple instructors and multiple classes of Modeling Instruction" paper is a summary for a study that lasted five years and built on the Colorado Learning Attitudes about Science Survey (CLASS)[Brewe et al., 2013]. The study was about modeling instruction classes for the calculus-based physics at Florida International University, which means a curriculum with a developed way of teaching and an explicit epistemological focus. In general, student attitude shifts are negative, as I discuss above. This paper reviews a collection of positive results that do exist, and adds a consistently positive set of shifts from the Modeling Instruction classes. Modeling curriculum classes are characterized by a small size and instructors, where students actively learn as scientists. These modeling classes that are using CLASS at Florida University found that there is increase in students' favorable responses during the semester, which supports the importance of epistemological features of classrooms and instructional environments.

[Madsen et al., 2015] published a meta analysis of 24 studies on how the choice of teaching method can impact students' beliefs about physics. The analysis tries to find how students' learning process can be affected by their beliefs. It also examined, how different methods of teaching affect students' views based on two main surveys: CLASS and MPEX. The study focuses on different factors that can change students' beliefs. First of all, the data showed that the traditional physics instruction gave a negative shift in both CLASS and MPEX surveys. On the other hand, instruction that is trying to increase students' expert-like beliefs resulted in a positive shift. Class size, student population and the pretest score were also other factors that were taken in account in this study. However, they didn't show a significant positive shift in students' beliefs. The cross-sectional studies, longitudinal studies, and comparisons between physics majors and other majors all show that students who major in physics enter their university education with more expert-like beliefs than others. Moreover, those studies found that these expert-like beliefs remain stable over the 4 years of their undergraduate major. In conclusion the analysis found that some of these 24 studies showed a positive relation between students' beliefs and the learning gain of physics courses, which also suggest that the more expert-like beliefs students have, the more knowledge and understanding they will get [Madsen et al., 2015] .

Jon D. H. Gaffney and Amy L. Housley Gaffney investigated student expectations, experiences and attitudes in an algebra-based active-learning physics course at Eastern Kentucky University [Gaffney and Gaffney, 2015]. Specifically, they sought to understand negative student comments that instruction in active-learning courses offers no learning benefit. This research is based on the Pedagogical Expectancy Violation Assessment (PEVA) which, given in pre-post format, assesses the expectations and experiences of students in the classroom. Previous research suggested that students who felt better about how each cluster of related activities was implemented were more satisfied with their course, but it was not known if this was related to the activity itself or how frequently (or how infrequently) it was done. Thus, the researchers modified the PEVA to ask questions which elicit a positive, neutral or negative response. The research found that students expected specific support from instructors, including feedback and encouragement, at the beginning of the semester. By the end of the semester, students generally experienced all instructor-related activities equally, such as classroom-led and individualized instruction. The research also found that more instructor-related activities led to greater satisfaction with the course.

Furthermore, students who did not enjoy individual effort or working with small groups were more likely to report low course satisfaction. The researchers speculate that this is because the students do not see tangible benefits from these activities. Thus, the study concludes that actual classroom events and activities determine student satisfaction rather than any predisposition or attitude students may have upon beginning the course.

2.3.4 Correlations Between Attitudes and Conceptual Understanding

Recently there have been several studies that focus on the relation between students' attitudes and their achievements [Madsen et al., 2015]. Those studies were conducted to see how students' beliefs can impact their understanding of physics. In this section we include some of these studies that focus on the significant and positive correlation between students' attitudes and their achievements in physics courses.

"Attitudes about science and conceptual physics learning in university introductory physics courses" is a paper using the CLASS survey in an introductory physics course at University of British Columbia in Canada [Milner-Bolotin et al., 2011]. Then, they compare their results with other universities. The research started in fall 2008 and studied students' conceptual learning and their attitude during their first year. Students were asked to answer the 42 CLASS survey statements. Conceptual understanding was measured using the FCI at the beginning and end of the semester. Uniquely, those courses that participate in this research were taught with a coherent and cohesive learning environment work, with advanced method of teaching that included collaborative group work, peer instruction, interactive lecture and computer simulation. The research found that in most CLASS categories students showed a positive shift and had more expert-like attitudes by the end of the semester, though this shift was only statistically significant for the "real world connections" category. "Sense making and/or effort" was the only category with a negative shift. The research also indicated that in all comparison data from other universities, were shown that students by the end of the semester had generally less expert-like attitude than when they started the semester, as has been commonly found with attitude surveys. There were many factors that may be the reason behind this result. One of them was the method of teaching at UBC, which might be the reason behind this average positive shift. Another important reason, is that students were chosen anonymous and participate voluntary without any extra credit. Equally important, this research studied the connection between students' attitudes about science and their conceptual understanding and found that it affected by whether students have taken physics courses before or not. Students who have taken grade 12 physics have higher positive relation between the FCI score and their favorable attitude. Moreover, they have more expert-like attitude over the semester comparing to students who have not taken grade 12 physics.

In 2005, Perkins and collaborators used correlations to explore and examine the relationship between students' attitudes toward physics and students' gain [Perkins et al., 2005]. This study uses the Colorado Learning Attitudes about Science Survey on over 750 students in Physics courses, in order to measure students' conceptual understanding, math physics connection, sense making, effort, real world connection, and personal interest. The study found that students who have more CLASS pretest percentage in catigories like: personal interest, real world connection, sense making and effort are more likely to have higher learning gain. Also, it highlighted the importance of students' interest towards physics which correlated with having higher students' ability to solve physics problems. As suggested in the study there is positive correlation between students' attitudes and conceptual understanding.

Gerd Kortemeyer investigates online student discussion behavior to identify student beliefs in his 2007 article "Correlations between student discussion behavior, attitudes, and learning"[Kortemeyer, 2007]. Observations, analysis surveys and guided interviews have several deficiencies in their methods of understanding student epistemological beliefs such as: students might act more ideally than in unobserved situations, since students are aware of being observed. To overcome these challenges, Kortemeyer designed a study which analyzed data collected through authentic online discussions— students approach their physics homework problems online— to investigate if correlations exist between personal epistemological beliefs and online peer discussions, and if they do, whether they correlate with measures of student learning. Koretmeyer collected data in an introductory calculus-based physics course for college-level students. Each contribution, or posting, was classified into one or more of the following categories: surface, procedural, conceptual, solution-oriented, mathematical, or physics. In addition, students participated on a voluntary basis in the Maryland Physics Expectations Survey (MPEX) at the beginning and end of the semester as well as an additional online survey to gauge students' perception of the online discussions. Then, student learning was measured by the Force Concept Inventory (FCI). The study reported correlations with r = 0.36 between the coherence cluster score on the MPEX and the course grade percentage. It also identified weak correlations between discussion behavior and MPEX, and a similarly weak correlation between MPEX and learning. The study did find that there is a strong negative correlation between solution-oriented discussion behavior and FCI score. Kortemeyer concludes that student online discussion behavior is not a pure reflection of epistemological beliefs, but the correlation between online discussion behavior and learning is stronger than the correlation between MPEX scores and learning.

2.4 Research Question

Based on those previous studies and our data which we analyse using Pearson's correlation, there are some correlations that were raised and we can study.

1. **CLASS-Pre vs. FCI-Pre** To what extent do students' incoming attitudes and beliefs impact their incoming conceptual understanding?

2. **CLASS-Pre vs. FCI-Post** Is there any impact of students' incoming attitudes and beliefs on their conceptual understanding at the end of their physics courses?

3. **CLASS-Pre vs. FCI-gain** Is there any connection between students' incoming attitudes and how much they gain from the physics course?

4. **FCI-Pre vs. CLASS-Post** Does having more incoming knowledge and understanding improve students' attitudes toward physics?

5. **CLASS-Post vs. FCI-Post** Do students' final attitudes affect their conceptual understanding by the end of the semester?

6. **FCI-Pre vs. FCI-Post** Is there any relation between students' incoming and outgoing conceptual understanding?

7. **Oshift vs. FCIgain** Can the shift in students' attitudes toward physics affect or be affected by the shift of their conceptual understanding?

Table 2.1 summarizes the seven correlations that were considered for this thesis project. It is worth to mentation that in this project "O" indicates the "Overall" on the CLASS test. Besides the overall percentage, we have category scores for Personal Interest, Senses Making/Effort and all other factors, but we do not consider them in this study.

Table 2.1: CLASS and FCI correlations,"O" here indicates "CLASS Overall"

Correlation	Variable 1	Variable
1	Opre	FCIpre
2	Opre	FCIpost
3	Opre	FCIgain
4	FCIpre	Opost
5	Opost	FCIpost
6	FCIpre	FCIpost
7	Oshift	FCIgain

Chapter 3

Methods

3.1 Institution and Class Contexts

As I will describe in the next chapters, our data was based on multiple kind of courses, which allowed for a great depth of understanding. For the purpose of examining, the study took place at Wright State University which began in 1964 as a branch campus of Miami University and Ohio State University. WSU is a large public university in the Midwest, located in Fairborn, Ohio. There are around 18,000 students (13,710 undergraduate students), with undergraduates around 76% of student body. The WSU student body is 70.6% white, 10.4% African-American, 30% non-traditional (student who over 25 years) as indicated by the office of Institutional Research. Wright State University took this name in honor of the Wright brothers, who invented the first airplane in the world in their Dayton bicycle shop.

Educational environments have strong impact on students' learning attitudes, and like the other universities the courses under this study were taught by different methods. Some courses were traditional classes, where the lecture is the centerpiece of the instruction and students passively receive information, take notes and then test their understanding with periodic exams. Other courses had full active classes using collaborative classroom activities, peer instruction, and cooperative problem solving exercises. The rest of the courses were 'half active', which might be a lecture with some use of collaborative activities. Generally, there were between 11 to maximum of 209 students in those courses, and sometimes it was a single professor, sometimes it was a professor plus undergraduate Learning Assistants and/or graduate student teaching assistants. Classes met for four hours of lecture and recitation per week, plus a separate two-hour lab. The data were obtained from Fall 2014 until spring 2016, as explained below.

The course that the students were enrolled in, divided in sections. First course (section A) is a large class with 209 students. This course was taught three times weekly for around an hour of lecture based instruction with some peer instruction, and a 50-minute recitation section with some cooperative group problem-solving. Second course (section D), was a general physics I with 188 students. Students in this course met for 80 min, two times each week. Sections B and C were taught by the same instructor and both of them were small scale (19 and 26 students). The next introductory course is section E which was also considerded as a small scale with only 29 students, who met twice per a week for one hour and 20 minutes. Our fifth course is a medium one, it has 104 students who met three times each week for around one hour of lecture. One medium course is section G with 71 students. The course taught by lectures/recitation three times per each week and last for one hour and 20 minutes. Last two sections (H and K) were a medium courses with around 120 to 122 students. While in section H students met twice a week for an hour and 35 minutes, students in section K met three times a week for one hour and 20 minutes at a time. Table 3.1 shows a summary for the sections that we examined.

Table 3.1: Comparison Courses Logistics: including class size, how much times they met each week and for how long time

Section	Class Size	Meeting Frequence	Class Length	Recitation
A	209	3x per week	55 min	Yes
B	19	2x per week	80 min	-
C	26	2x per week	80 min	-
D	188	2x per week	80 min	-
E	29	2x per week	100 min	Yes
F	104	3x per week	60 min	Yes
G	71	3x per week	80 min	Yes
H	122	2x per week	95 min	-
K	120	3x per week	80 min	Yes

3.2 Data Collection

Over the last few years, there has been a strong concern and demand to improve physics education, which resulted in having different instruments or surveys that measured students' beliefs, expectations and understanding of physics. In our study we rely on two of the most common surveys in PER, which are the Colorado Learning Attitudes about Science Survey and the Force Concept Inventory. CLASS survey was used in this study to measure students' attitudes toward physics whereas FCI was used to measure their understanding of physics. Then the measurments results were correlated to each other to see the impact of each one of them on the another one.

3.2.1 CLASS

In order to develop students' questioning, researching, problem solving and critical thinking they should be improved regarding, we have to increase their knowledge, understanding and attitude towards sciences. The Colorado Learning Attitudes about Science Survey (CLASS) physics version is a newly adapted instrument designed to measure students' beliefs about physics and learning physics, and compare novice to expert-like perceptions. It is established to measure the impact of students' beliefs on their understanding and learning of physics in order to develop physics instructions. The Survey probes various aspects of students' attitudes about physics to obtain meaningful understanding about:

- Learning physics
- The content of physics knowledge
- The structure of physics knowledge
- The connection between physics and the real word

The CLASS survey (given in Appendix A) has 42 statements that students answer using a 5-point Likert scale. Those statements probe students' beliefs about physics in general, not about a specific course. The statments are divided into eight statistically robust categories and our concentration is on the overall. Datas were collected using "Qualtrics" where students have pre and post test, and those answers collected at the first and last weeks of each semester then we calculated the shift. Then we measured the average percentage of statements by taking the favorable score that are more expert-like answers. The next few statments are examples of statements included in this survey:

A significant problem in learning physics is being able to memorize all the information I need to know.

When I am solving a physics problem, I try to decide what would be a reasonable value for the answer.

I think about the physics I experience in everyday life.

3.2.2 FCI

Students certainly enter physics courses with a common-sense beliefs about Physics concepts and how the physical world actions work, which form from their personal experiences over many years. David Hestenes, Malcolm Wells, and Gregg Swackhamer had established the Force Concept Inventory (FCI), it is a similar test that was designed in the late 1980s/early 1990s to measure student understanding of basic concepts in Newtonian physics. The 30 questions over these concepts covered with six dimensions of Newtonian mechanics, such as Newton's first, second and Third laws [Hestenes et al., 1992]. In another words FCI is measuring more students' concepts understanding whereas CLASS test is measuring students' beliefs and expectations about physics. The data that we collected for the FCI were taken during the lab class (Fall 2015 and Spring 2016) or in the lecture class (Fall 2014 to Summer 2015) and students answered on a paper based survey. Also, students had to do pre and post test then we calculated the gain by taking the increase in the number correct.

It is important to mention that there are two kinds of gain that are usually measured: normalized gain (which is the standard measure for reporting many research results for FCI) and raw gain (which we are considering in our study). The normalized gain measures the effectiveness of a class in promoting conceptual understanding and was defined by Hake [1998] as:

$$\langle g \rangle = \frac{\langle post\% \rangle - \langle pre\% \rangle}{100 - \langle pre\% \rangle} \tag{3.1}$$

The brackets indicate the average pre percentage correct and average post percentage correct for the class, so this is a measure of the average amount that was gained relative to what was possible. It is important to mention that the normlized gain has divided by Hake to three degree ″High-g″ courses with g > 0.7 , "Medium-g" courses with $0.7 > g > 0.3$ and "Low-g" courses with $g < 0.3$. On the other hand, the raw gain "shift", which we considered in our study, is the final (post) minus initial (pre).

3.3 Attitudinal and Conceptual Correlations

The purpose of this section was to find out whether students' attitudes toward Physics have a connection with their achievements, both at the beginning and the end of their introductory undergraduate college physics class. Relationships between those attitudes and conceptions have been the focus of several previous studies. Significant correlations were found between student attitudes and conceptual understanding. Here we look for this correlation and measure it using Pearson's correlation.

3.3.1 Pearson's Correlation

Among scientific colleagues, the word correlation used to refer to connection, link, or any kind of association. Pearson's correlation full name is Pearson Product Moment Correlation or PPMC. It is a statistical model measures the strength of linear relationship between two continuous sets of data, which indicates how well they are related. Pearson's correlation coefficient denoted by symbol of **'r'** or **'ρ'** can used only if we have a linear relationship. The coefficient value can range between - 1 to 1. So, if we have a positive correlation that means both given variables have a tendency to increase. Negative correlation means one of the variables increases while the other variable has decrease. If the one of the variables have no tendency to increase or decrease with the other we will have no correlation. The equation 3.2 is showing how to calculate ρ.

$$\rho = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{3.2}$$

The next table 3.2 shows Pearson product coefficient categories divided from very weak to very strong correlation.

Table 3.2: Pearson Product Categories

ρ	The correlation
0.00 - .19	Very weak
.20 - .39	Weak
.40 -.59	Moderate
.60 - .79	Strong
.80 - 1.0	Very strong

3.4 Data Analysis

In this report we use RStudio [R Core Team, 2016] to run all correlations. What is R program? R is a data processor program and statistical analysis language. It can do many things on the data given, characteristic of the program is the ease and speed of use in addition to its accuracy. The results of this investigation are calculated from previous CLASS and FCI datasets which were imported to RStudio, then matched using students' UIDs and scored to get the favorable responses for each test.

Chapter 4

Results

4.1 Data Description

The results of this analysis contain nine semesters of data that use CLASS and FCI surveys in each section (only section D has no FCI data). We first start by introducing the CLASS data summary, which includes the favourable percentage for each section, then the FCI data summary. The last part of this chapter shows the possible correlations that we measured between those two dataset.

Table 4.1 provides the total number of students who were enrolled at the beginning (pre) and the end (post) of each semester or section we studied.

Table 4.1: Enrollment in the first and last weeks of the semester for each section

Section	Pre	Post
A	215	209
B	26	19
C	28	26
D	192	188
E	29	29
F	118	104
G	65	71
H	125	122
K	125	120

The next table, table 4.2 provides additional details on the participation rates (calculated by dividing the number of students actively participating by the total number of students who are eligible to participate) for each test. Also, it has participation rates for students who took both surveys in each section. Sections with a statistically significant outcome (participation rate is more than 50%) such as sections A and H will be our focus to analyse. On the other hand, for insufficient data such as sections B, C and F we will ignore it because it has a small number of students that might not be useful in finding statistical significance in the correlations.

Table 4.2: Participation rates for the pre, post (in percentages) and matched scale; matched columns give raw values instead of percentage. Section K had a very low post FCI participation rate, so we ignore any correlation involving FCI post or gain for that section.

	CLASS			FCI			Both		
Sections	Pre	Post	Matched	Pre	Post	Matched	Pre	Post	Matched
Section A	77 %	51%	92	89%	73%	136	70%	56%	111
Section B	68 %	67%	10	92%	63%	10	85%	44%	6
Section C	65 %	63%	15	100%	80%	19	71%	50%	13
Section D	71 %	65%	92	-	-	-	-	-	-
Section E	72 %	65%	14	86%	59%	13	59%	45%	8
Section F	33 %	25%	11	81%	66%	57	28%	17%	6
Section G	68 %	44%	23	86%	63%	35	59%	34%	17
Section H	71 %	67%	65	85%	75%	87	62%	52%	47
Section K	74 %	73%	71	96%	20%	24	63%	9 %	10

4.2 Descriptive and Exploratory Statistics for the CLASS

A histogram is a visual representation of the distribution of a given dataset, that is similar to bar chart but with grouping the data into ranges. It helps us to easily see at which point there is large amount of data and at which point it is decreases. For this reason, we start with histograms showing our CLASS data for section A 4.1, 4.2, 4.3 below to show the pre, post and the shift scores for the CLASS test (A) separately.

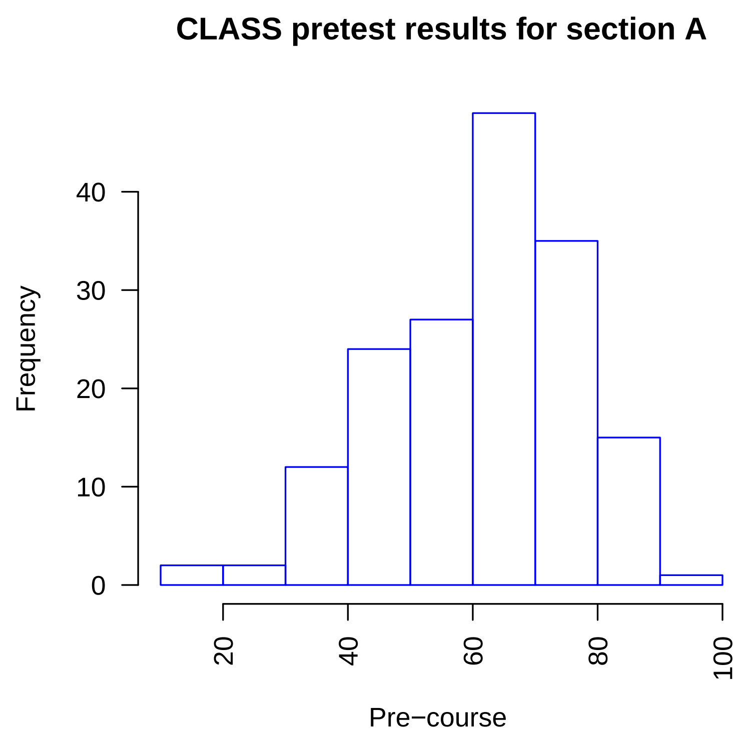

Figure 4.1: Histogram of CLASS pretest results for section A

The histograms show the CLASS pre, post and shift course scores for section A. The x-axis is plotting the CLASS percentage, while the y-axis is showing how many people there were for each percentage favorable bin. Both the pre and the post histograms show the frequencies of CLASS for the students at the beginning and the end of semester respectively. Clearly we can see the peak for pre test (between 60- 70). Whereas the peak level of the post test flattened out and became between 60- 80.

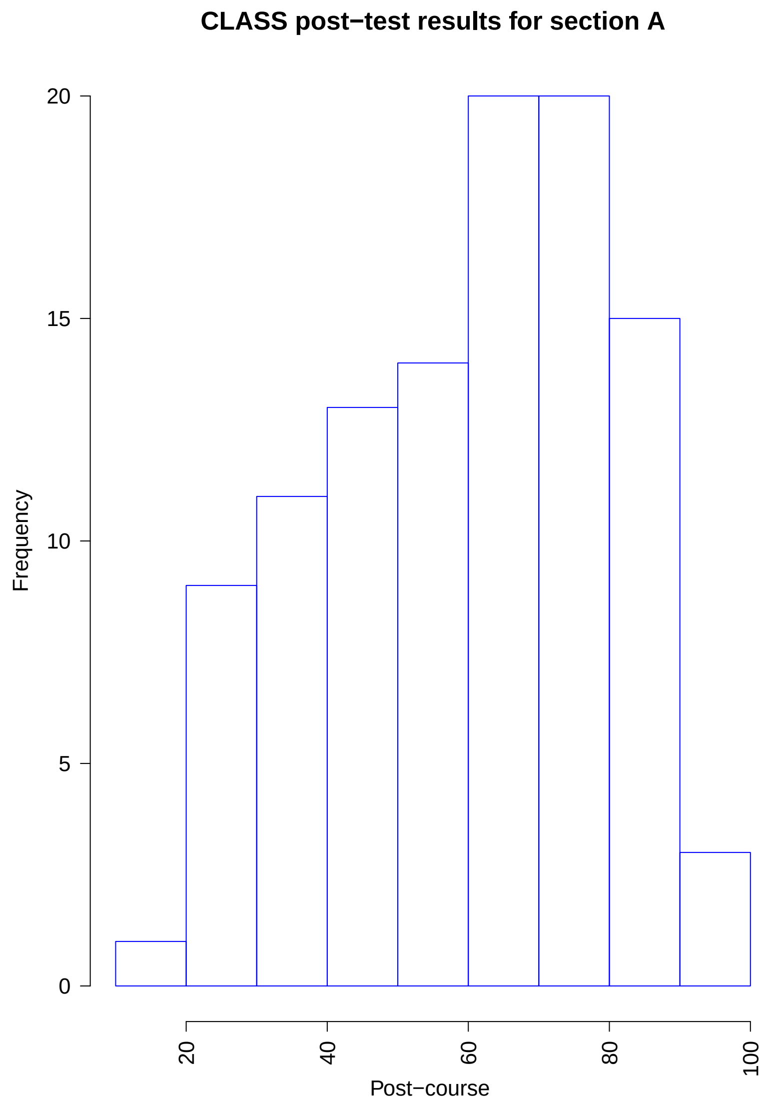

Figure 4.2: Histogram of CLASS post-test results for section A

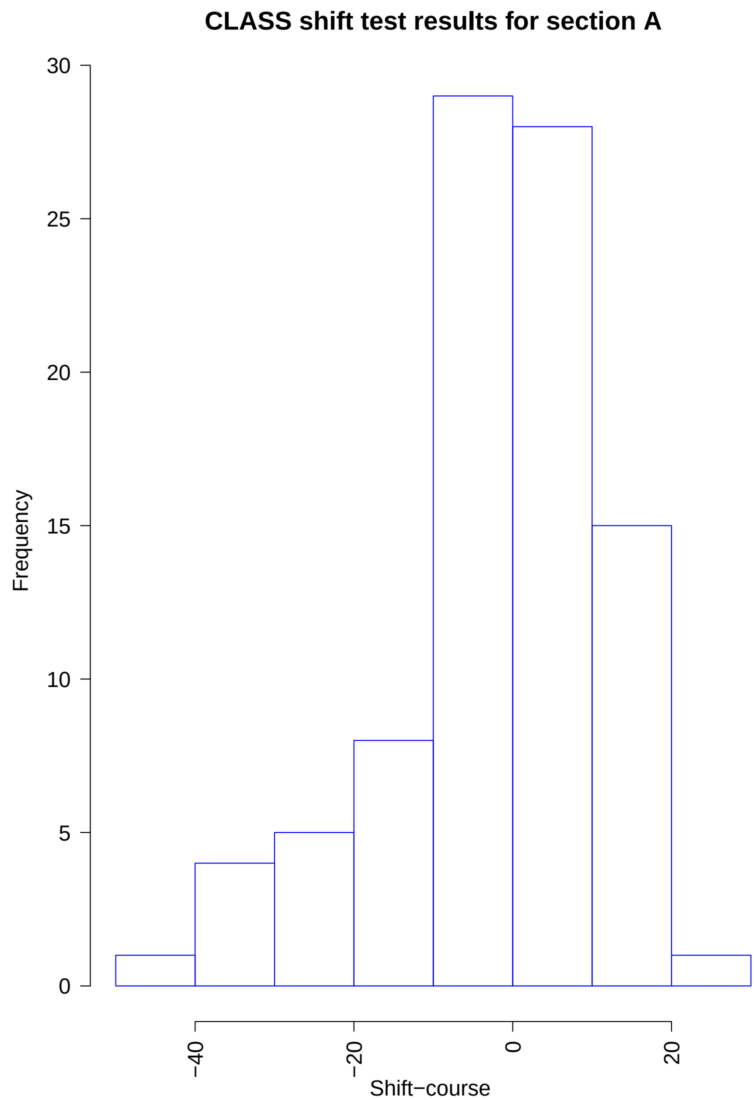

Figure 4.3: Histogram of CLASS shift-test results for section A

For more understanding, figure 4.4 shows a boxplot for section A pre and post test scores. Boxplots divide data into four equal sized groups, where each group is 25% of the total obtaining CLASS scores. The horizontal lines mark quartiles, which show important information for the given data. First, the thick black line shows the median (middle quartile), which marks the middle point of the data. It divides the box to two parts, which show the two greater and less than the half scores are. Secondly, the upper level of the box, that 75% of the scores fall below it and the lower quartile, that 25 % of the scores fall below it. Also, the upper and lower "whiskers" show the top and bottom 25% of the data. For more information see [McGill et al., 1978]. Notice that both datasets are approximately balanced around 63%. However, there is more variation in the CLASS post result which ranges approximately from 10 to 100 while the pre result ranges approximately from 25 to 95.

The average percentage of the pretest was 61.6% favorable, while by the end of the semester (for section A) students' attitude decrease to reach 59.6% favorable. This suggests that students arrive at university with positive attitudes in the introductory course, yet they end with less expert-like attitudes. Many sections had larger negative shifts.

The next graphs 4.5,4.6, 4.7, show side-by-side boxplots of CLASS pretest for the nine sections to compare them. The X-axis is about different section names from A to K and the Y axis is the percentage of favorable responses. The thick line in the center is the median which is the midpoint of each class and the other quartiles are the values where the range is deviated.

In graph 4.5 it appears that section A, B, D, F, G, H and K have similar centers, which are 60% and more, exceeding section C and E. Section A and D appear to have more variability than the other sections, because they are wider— the width is scaled by the square root of the number of students N. Sections A, D, F, G, D

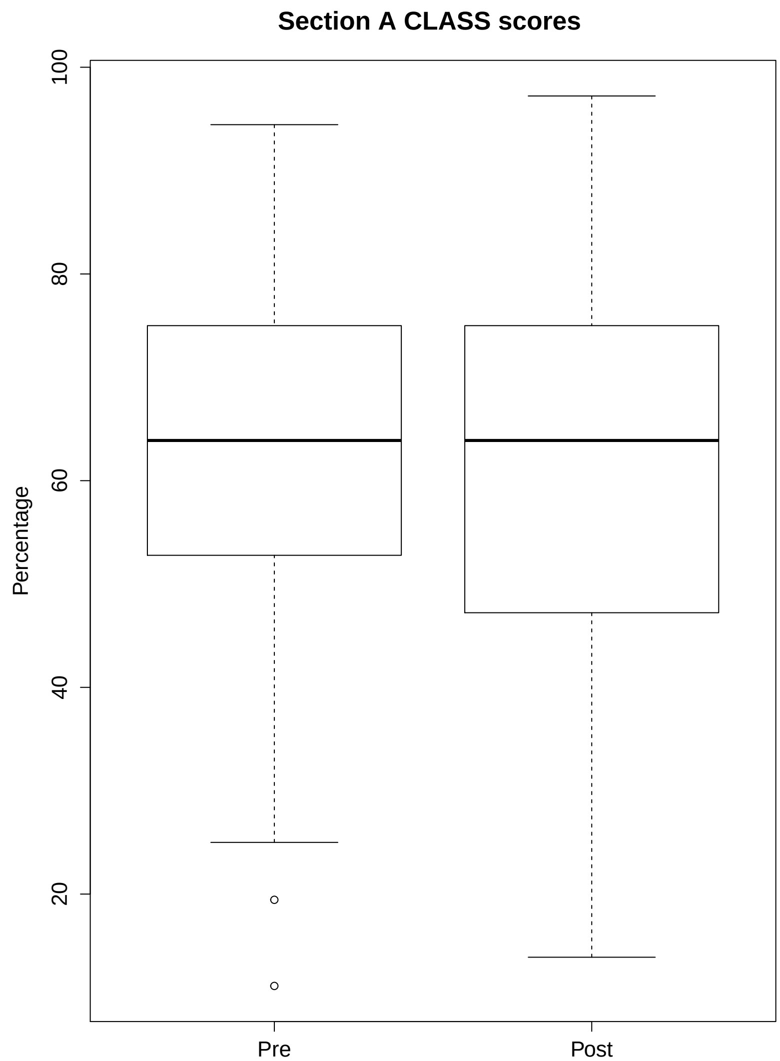

Figure 4.4: Pre and Post CLASS results for section A

and K are reasonably symmetric, but section B, C and E skewed to the top and the bottom. The notch here shows the 95% confidence interval for the medians. If the notches from two box plots do not overlap, we can assume at the 0.05 significance level the medians will be different.

A general overview on 4.6 figure shows that most of the section favorable percentages were decreased or slightly decreased. This suggests that students' attitudes toward physics decrease by the end of the semester, despite the high positive attitudes that students had at the beginning of the semester.

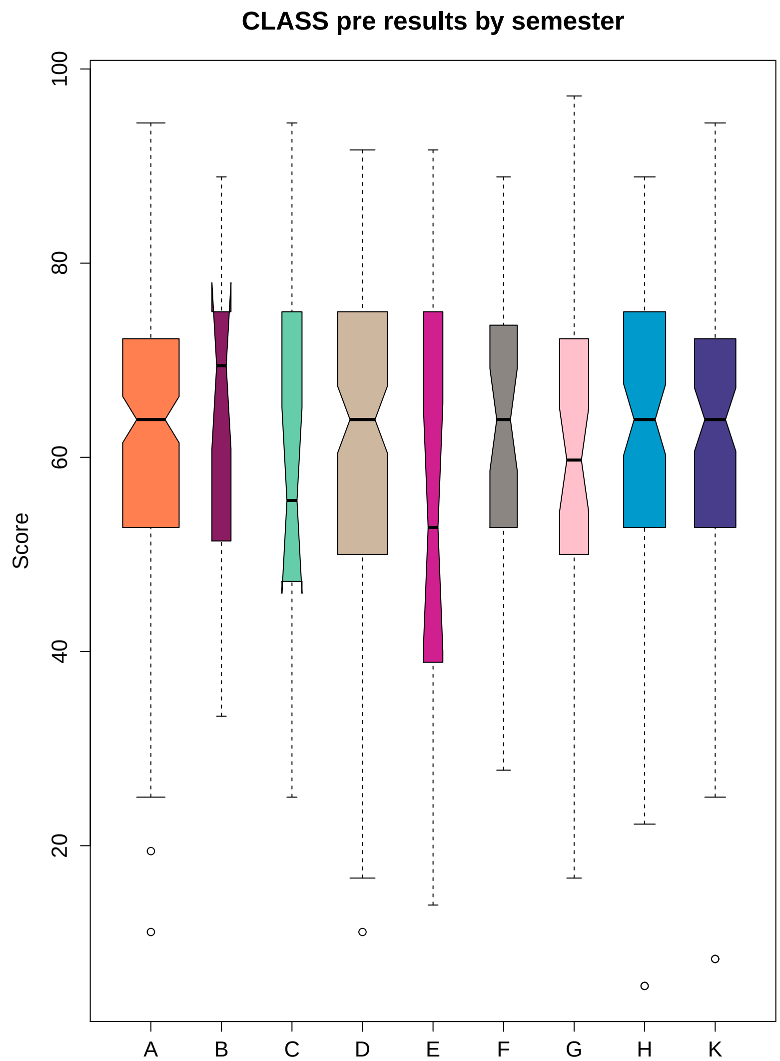

Figure 4.5: Pre CLASS results for all sections

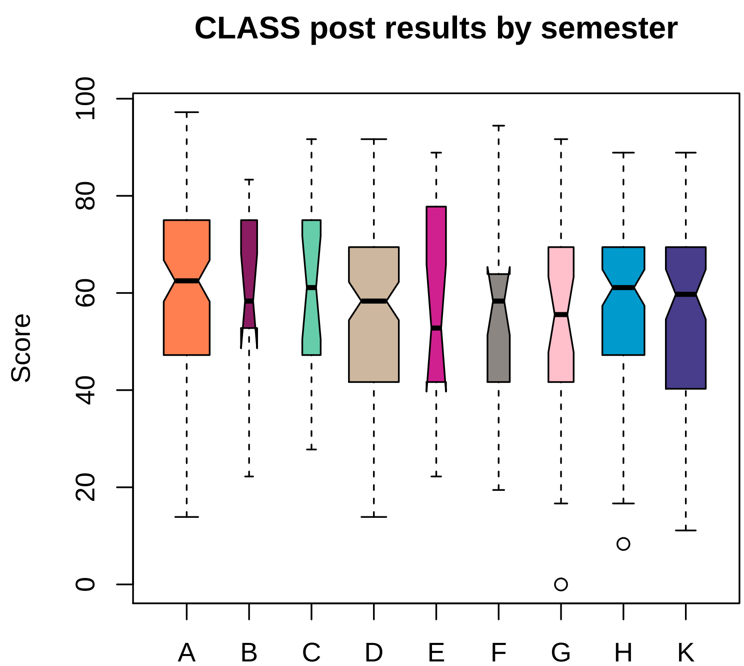

Figure 4.6: Post CLASS results for all sections

Figure 4.7: Shift CLASS results for all sections

Table 4.3 shows the 9 sections that we collect our data from. It shows for each section the pre, post and the shift tests and our focusing on the mean for the overall. Moreover, it has the number of students who took each test. Also the table shows the standard deviation for each test, which measures how separate our datasets are from their means. Effectively, it helps us to understand the normal distribution. The sample standard deviation formula is [Biau, 2011]:

$$sd = \sqrt{\frac{\sum(y_i - y)^2}{N}} \tag{4.1}$$

where y is the average value.

Table 4.3: Averages of the percentage of favorable responses (students agreeing with experts), number of students and the standard deviations in each CLASS test "pre, post and shift"

Section	Npre	Pre	Sdpre	Npost	Post	Sdpost	Nshift	Shift	Sdshift
A	166	61.6	15.3	106	59.6	19.4	91	-2	13.6
B	17	64.2	15.5	12	58.55	19.62	10	-6.4	9
C	20	60.3	19.5	17	61.3	7.6	15	5.4	7.75
D	130	61.8	16.5	125	56	17.9	92	-4.9	16
E	21	55.3	23.4	19	60.1	20.6	14	2.8	16.5
F	39	63.7	15.25	26	54.2	19.5	11	-10.4	15
G	44	59.4	17.7	31	55.7	21.4	23	-1.2	14.6
H	89	61	17.04	80	55.9	17.71	65	-5.3	17.2
K	92	61.9	18.1	89	58.7	55.9	65	-2.9	14.2

4.2.1 Comparison with other CLASS Results

Figures 4.8,4.9, 4.10 show the comprising of our results for the nine sections (A to K) with results previously published by Adams et al. [2006], Perkins et al. [2005]. These bar charts represent the CLASS pre, post and shift scores compared to other results. In those Figures, students were scored by their average percentage favorable result and plotted the percentage of students within each section. As we can see blue column has Adams's overall, yellow columns have 6 different sections for Perkins's overall, and the rest of the columns have the Wright State University overall attitude.

The bar charts has highest peak for one of the Perkins sections and lowest peak for semester E. Similarly graphs are constructed based on their values for other post and shift scores. These averages correspond to regarding the table shown above. It represents the number of students in each semester and their datasets spread across the mean. This clearly shows how the data is distributed for the CLASS pre, post and shift scores.

The pre CLASS figure shows similar overall percentage favorable in students' attitudes. Section E that has the Wright State University students shows a low overall comparing to other courses, that might be as a result of having small class (with 14 students).

The post CLASS figure shows a general drop of student attitude by the end of the semester, especially for Adams and Wright State's nine sections. Unfortunately, there were hopes of increasing students' attitude toward physics courses but the results show different thing. There were only 3 sections in Perkins's results that showed a slight increase or even stable overall attitude.

As a result, the shift CLASS figure shows an overall decline in students' attitude, except some sections that considered before as a small class that might not help with generalizing their trends.

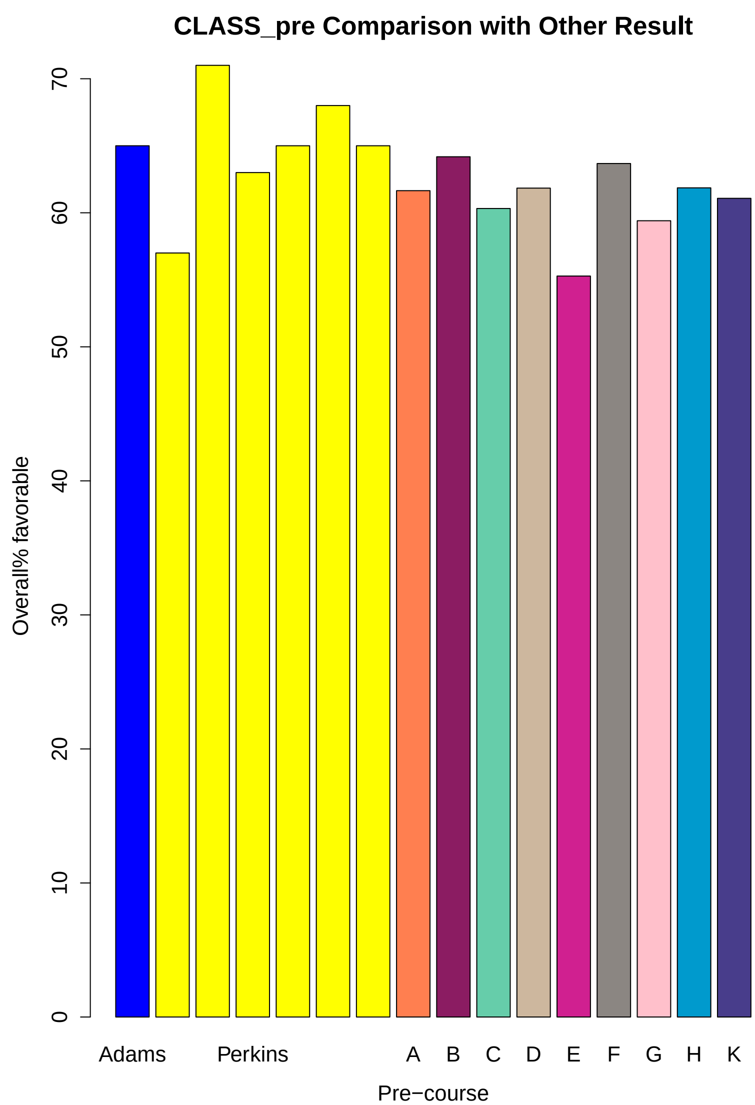

Figure 4.8: CLASS pre-test results comparison, our study result with Adams et al.'s and Perkins et al.'s results. Each color indicates a different section, however Perkins' study had more than one section.

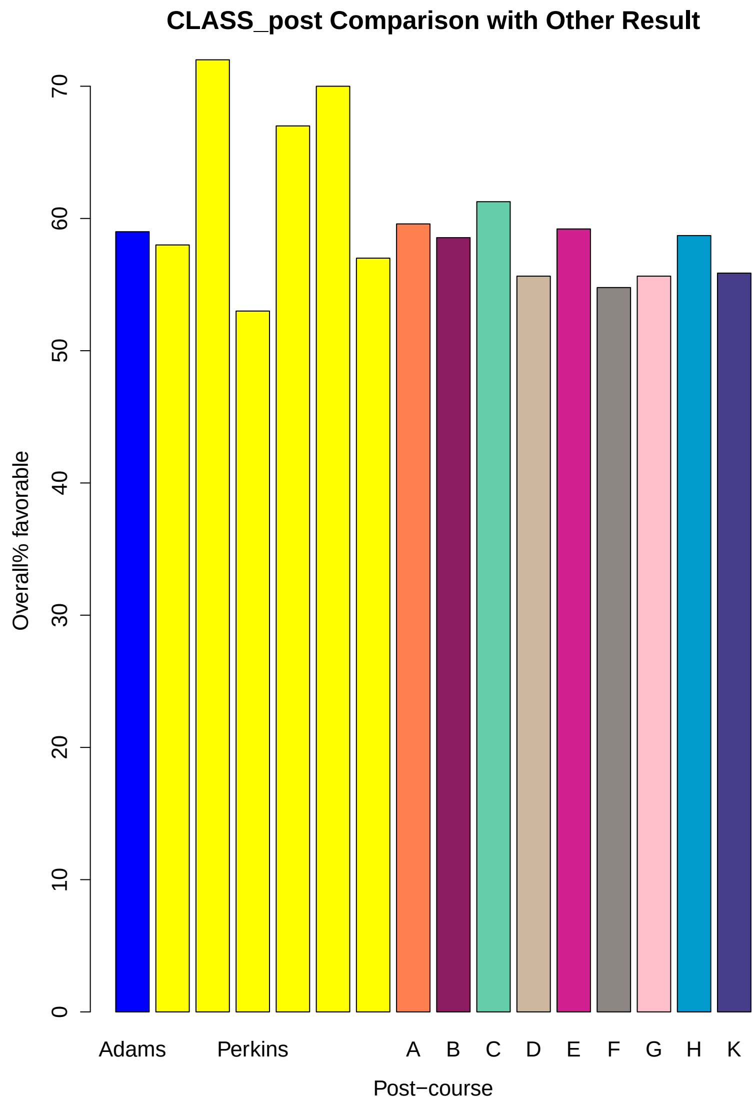

Figure 4.9: CLASS post-test results comparison, our study result with Adams et al.'s and Perkins et al.'s results.

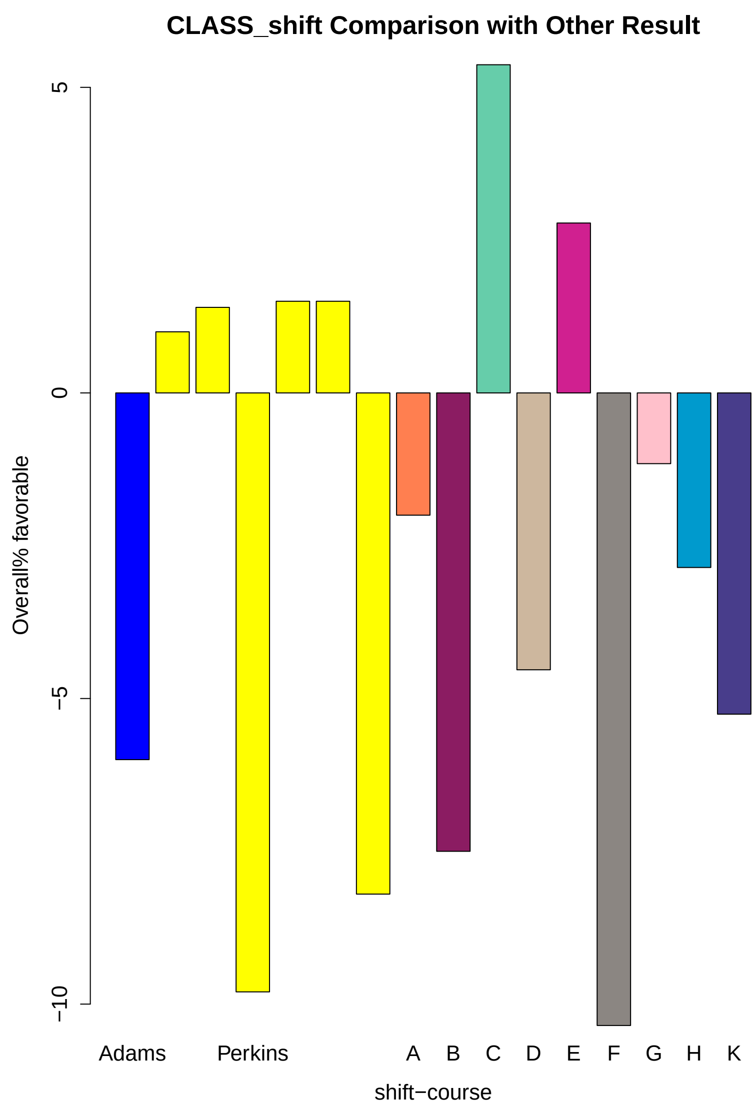

Figure 4.10: CLASS shift-test results comparison, our study result with Adams et al.'s and Perkins et al.'s results.

4.3 Descriptive and Exploratory Statistics for the FCI

In this section, we used the FCI pre, post and gain to evaluate the students' conceptual understanding for all sections. The overall FCI results data for section A is shown in 4.11, 4.12,4.13 in detail.

Figure 4.11 shows the FCI pretest results for section A where the y-axis on these histograms shows frequency, x-axis shows their score on the FCI. It is noted that the largest number of students, a bit over 80, scored in the 5-10 range on the pretest. That peak was smaller on the post-test plot, where we can also see that students mostly shifted to higher scores (because the bars to the right of the 5-10 range are now higher).

Figure 4.12 shows the post-test results for section A also in terms of their frequencies and once again 5-10 students were most common among all. However, it is important to notice that the number at this peak of scores is only 50 compared to the pre-test which was over 80.

Looking at the shift-test results in Figure 4.13, it is evident that the highest number of students shifted 0-2 points in their total score. While this is a very small number, it is important to notice that the general trend of the shifts is in the positive values and not in the negatives. That means there were more favorable answers from students as seen from the shift figure and this suggests increase in students' conceptual understanding.

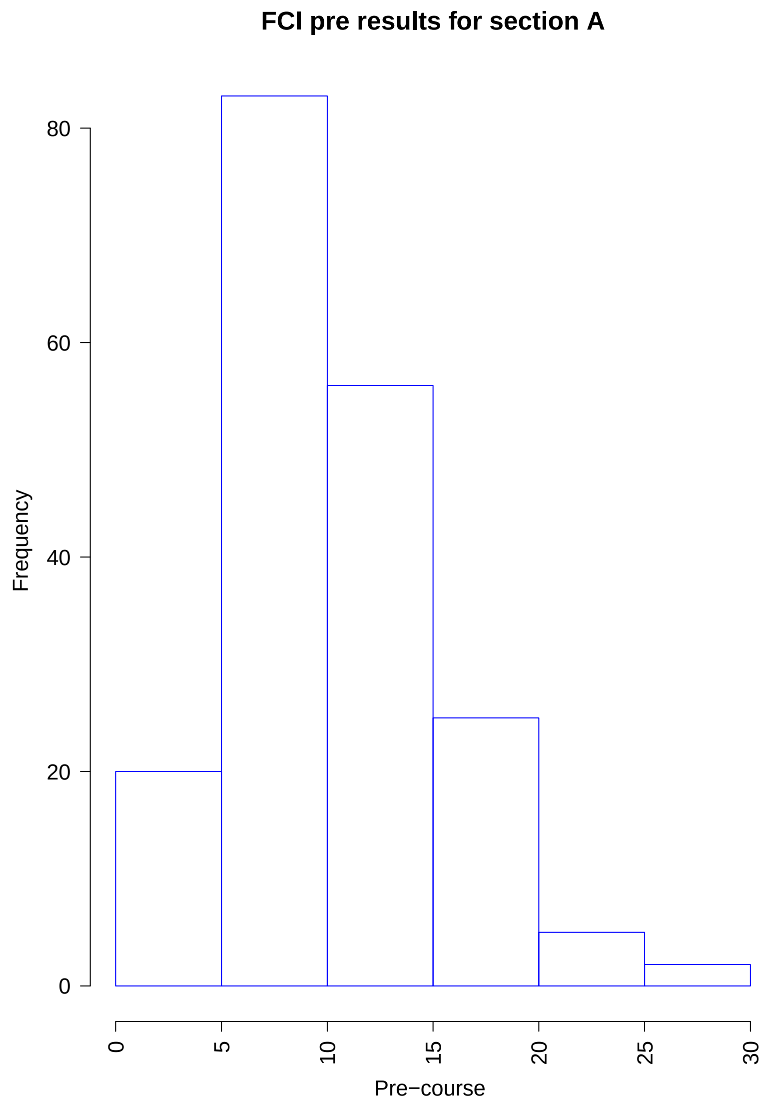

Figure 4.11: FCI pre results for section A

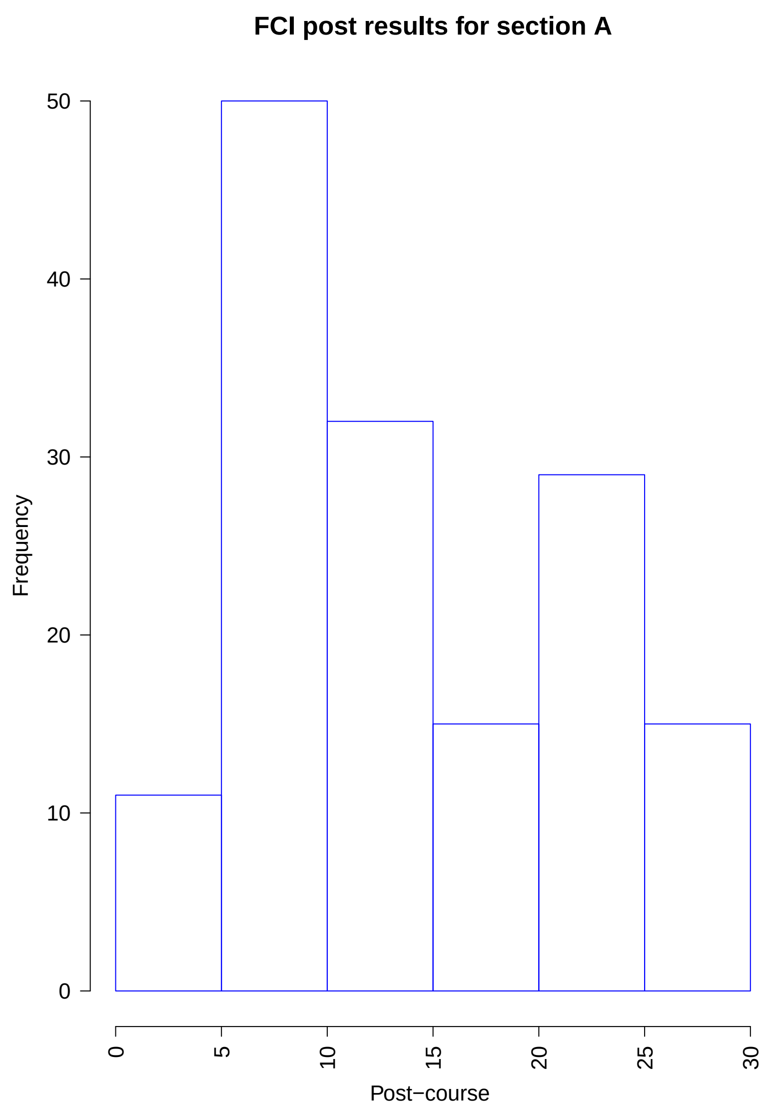

Figure 4.12: FCI post results for section A

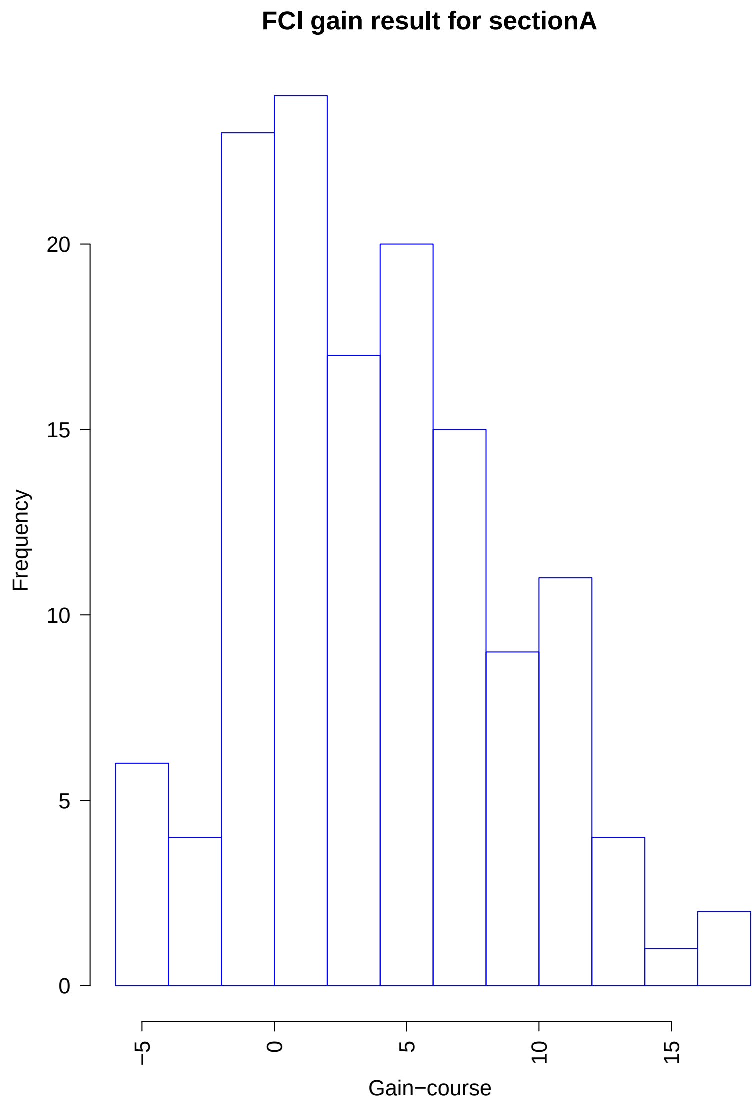

Figure 4.13: FCI gain results for section A

The next three boxplots 4.14,4.15 and 4.16 show the pre, post and the shift-course FCI scores for each section. The median of the boxplot shows as the "waist". FCI pre scores showed a similar median for all semesters except for section E, which is very small. The FCI average post scores are less uniform, and have more variance, as shown by having larger slanted-line regions around the "waist".

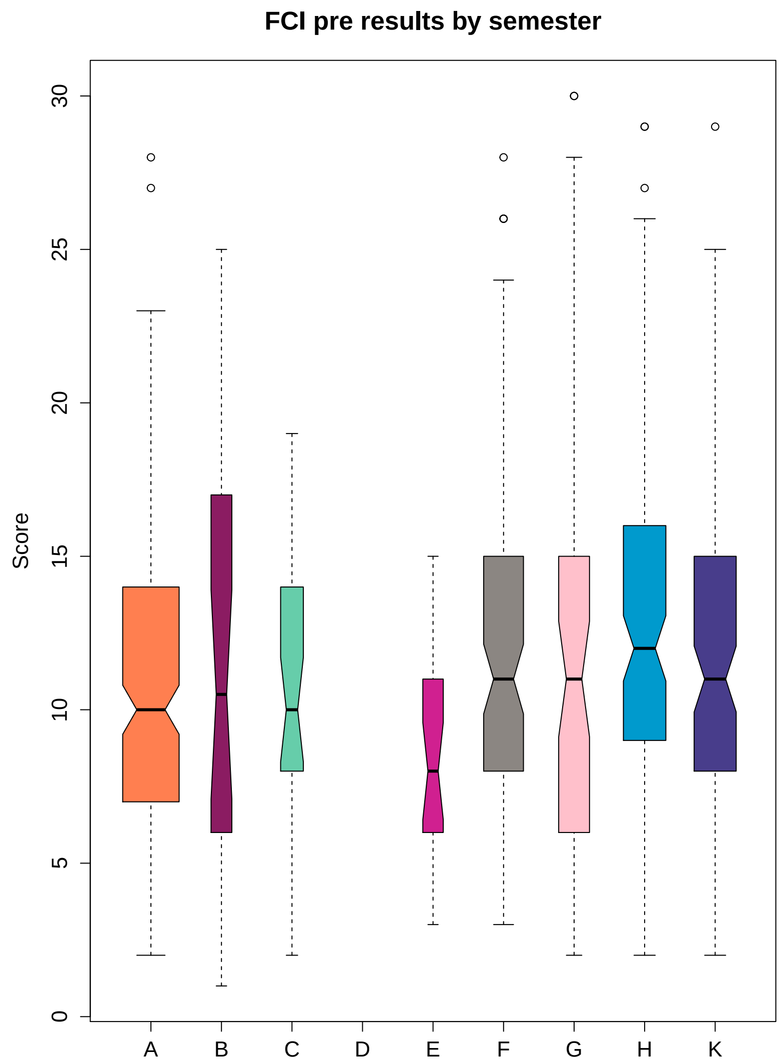

Figure 4.14: FCI pre results for all sections

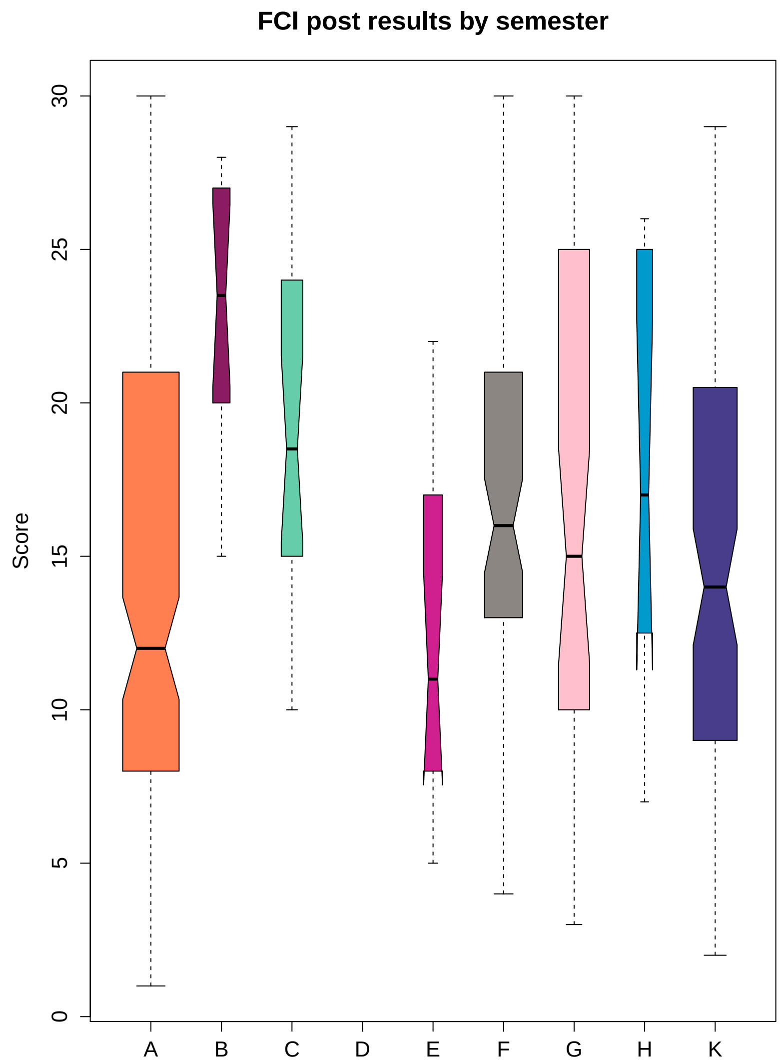

Figure 4.15: FCI post results for all sections

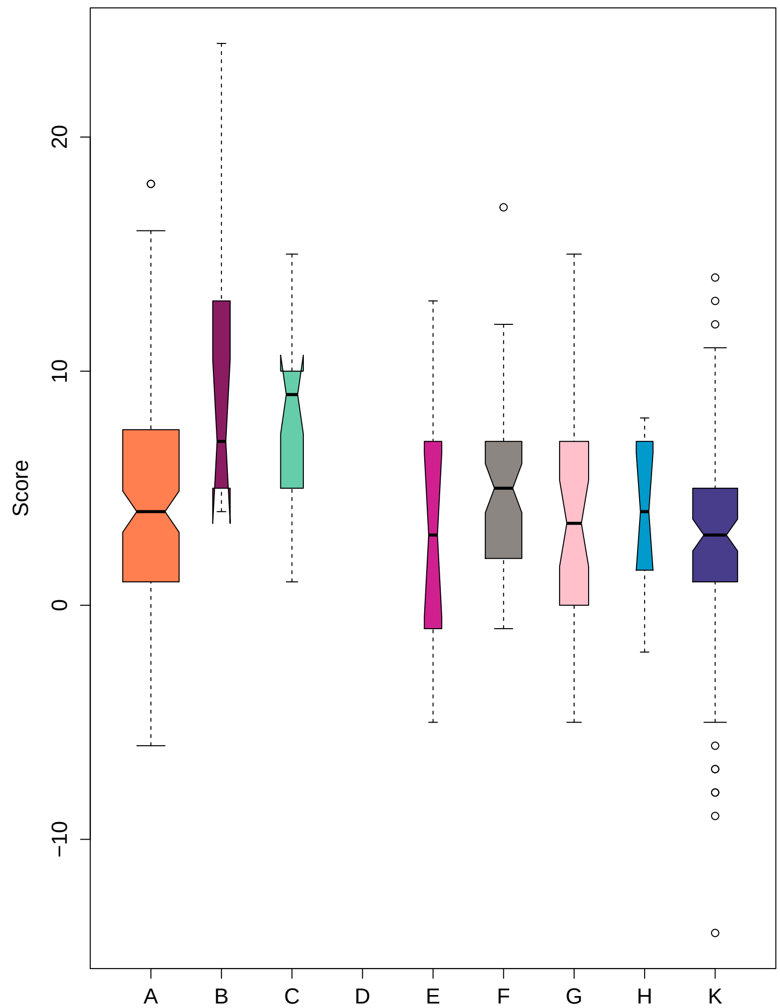

Figure 4.16: FCI gain results for all sections

4.4 Correlations Between CLASS and FCI Scores

Research in physics education has emphasized that students' attitudes contribute to learning physics due to the fact that students bring significant expectations into classrooms. In this section students' responses for the CLASS test (pre and post), that measures their attitudes, were compared with the responses of FCI test (pre and post), that measures their academic performance, in order to empower us to create connections between them. The next few tables show the test we are doing and the number of students for both of them. The tables also correlation coefficients rho, P-values for them and the 95% confidence intervals. The "rho" here tests whether the two variables (paired samples) are uncorrelated using Pearson's product moment correlation coefficient.

Table 4.4 shows the correlation between pre and post tests for CLASS and FCI tests for section A. The information presented in this table contains the significant and nonsignificant correlations. Table 4.4 shows the number of the students N which were available for each correlation. Also, it has the the p-value, that determines the significance of our results and indicates the probability of having a result equal to or more than what was actually observed. P-values less than 0.05 are considered statistically significant.

The next few tables provide same information for each section we have in this study, for more clarification.

Table 4.4: Shows the seven correlations between CLASS and FCI tests for section A: with each correlation it includes number of students, ρ, P-value and 95 percent confidence interval,

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	152	0.377	1.648e-06	[0.232, 0.506]
Opre	FCIpost	116	0.516	3.113e-09	[0.368, 0.638]
Opre	FCIgain	111	0.339	0.0002	[0.163, 0.494]
FCIpre	Opost	98	0.164	0.107	[-0.0369, 0.351]
Opost	FCIpost	97	0.218	0.053	[-0.003, 0.419]
FCIpre	FCIpost	122	0.736	$< 2.2e-16$	[0.642, 0.808]
Oshift	FCIgain	47	-0.228	0.12	[-0.484, 0.063]

Table 4.5: CLASS and FCI Section B

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	15	0.407	0.132	[-0.133 , 0.761]
Opre	FCIpost	8	0.435	0.282	[-0.389 , 0.872]
Opre	FCIgain	8	0.155	0.715	[-0.617 , 0.775]
FCIpre	Opost	12	-0.079	0.276	[-0.288 , 0.766]
Opost	FCIpost	7	0.640	0.122	[-0.219 , 0.940]
FCIpre	FCIpost	10	0.198	0.584	[-0.493 , 0.736]
Oshift	FCIgain	6	0.524	0.286	[-0.500, 0.937]

Table 4.6: CLASS and FCI Section C

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	20	0.389	0.0901	[-0.065 , 0.709]
Opre	FCIpost	16	0.302	0.257	[-0.228, 0.694]
Opre	FCIgain	16	-0.057	0.833	[-0.538 , 0.451]
FCIpre	Opost	17	-0.174	0.505	[-0.604 , 0.335]
Opost	FCIpost	13	0.165	0.59	[-0.425 , 0.656]
FCIpre	FCIpost	18	0.702	0.001	[0.349 , 0.88]
Oshift	FCIgain	8	0.064	0.880	[-0.671 , 0.736]

Table 4.7: CLASS and FCI Section E

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	17	0.15	0.57	[-0.357 , 0.588]
Opre	FCIpost	13	0.268	0.377	[-0.332 , 0.713]
Opre	FCIgain	11	0.113	0.741	[-0.522 , 0.668]
FCIpre	Opost	15	-0.079	0.777	[-0.569 , 0.451]
Opost	FCIpost	13	0.132	0.667	[-0.452 , 0.637]
FCIpre	FCIpost	13	0.408	0.167	[-0.185 , 0.783]
Oshift	FCIgain	8	0.064	0.880	[-0.671 , 0.736]

Table 4.8: CLASS and FCI section F

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	33	0.305	0.085	[-0.043 , 0.587]
Opre	FCIpost	29	0.539	0.003	[0.215 , 0.756]
Opre	FCIgain	25	0.228	0.273	[-0.184 , 0.572]
FCIpre	Opost	22	-0.055	0.809	[-0.466 , 0.376]
Opost	FCIpost	18	-0.36	0.143	[-0.708 , 0.129]
FCIpre	FCIpost	35	0.821	1.557e-09	[0.671, 0.906]
Oshift	FCIgain	6	0.286	0.583	[-0.685, 0.891]

Table 4.9: CLASS and FCI section G

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	38	0.055	0.74	[-0.27 , 0.37]
Opre	FCIpost	30	0.163	0.389	[-0.209 , 0.494]
Opre	FCIgain	25	-0.219	0.293	[-0.565 , 0.193]
FCIpre	Opost	30	0.144	0.449	[-0.229 , 0.479]
Opost	FCIpost	24	0.004	0.985	[-0.4 , 0.41]
FCIpre	FCIpost	29	0.840	1.812e-08	[0.675, 0.92]
Oshift	FCIgain	17	0.265	0.304	[-0.247 , 0.661]

Table 4.10: CLASS and FCI section H

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	79	0.321	0.004	[0.108, 0.51]
Opre	FCIpost	11	0.44	0.177	[-0.218 , 0.822]
Opre	FCIgain	11	0.41	0.212	[-0.254 , 0.809]
FCIpre	Opost	77	-0.074	0.522	[-0.293 , 0.152]
Opost	FCIpost	11	-0.202	0.551	[-0.715 , 0.453]
FCIpre	FCIpost	12	0.926	1.519e-05	[0.752 , 0.979]
Oshift	FCIgain	10	0.13	0.72	[-0.544, 0.702]

Table 4.11: CLASS and FCI section K

Variable 1	Variable 2	N	ρ	P-value	95 percent confidence interval
Opre	FCIpre	77	0.286	0.011	[0.066 , 0.479]
Opre	FCIpost	69	0.382	0.001	[0.16 , 0.568]
Opre	FCIgain	65	0.212	0.089	[-0.033 , 0.434]
FCIpre	Opost	69	0.073	0.55	[-0.166 , 0.305]
Opost	FCIpost	63	0.203	0.112	[-0.047 , 0.429]
FCIpre	FCIpost	75	0.649	2.832e-10	[0.496 , 0.764]
Oshift	FCIgain	47	0.265	0.123	[-0.484, 0.063]

Chapter 5

Discussion and Conclusions

The findings of this paper put up the framework for discussion and further research. The goal of this study is using large sample of introductory physics students, which has multiple instructors and populations to determine the strength of the relationship between their attitudes and their understanding of introductory physics courses. For this study, the instruments used to measure this correlation are CLASS and FCI tests. Many university students have low performance in introductory physics courses more often than not, our contents in this study support the correlation between the students' attitudes and the students' conceptual understanding, which will enhance their performance; even though the results were not found to be statistically significant in all sections.

Results from the pre CLASS revealed similar overall percentage favorable in terms of students' attitudes with an exception of section E at Wright State University which may be due to low number of students. Apart from that, the trends look positively consistent. This shows that current research indicated positive correlation with the published results. In terms of the post CLASS results, a general drop of students' attitude by the end of the semester is seen, more noticeably for Adams and all sections of Wright State University. A part from only three sections in Perkins' results that showed stable attitudes, all others showed significantly decreased attitudes towards physics. While this is somewhat unexpected for this research, the results do correlate with some published results. Overall decline in students' attitudes was seen in the shift CLASS except for a few sections. Regardless of the incline in a few sections with exceptional incline from section C of Wright State University, the trends cannot be generalized positively. Since similar results were seen in the published results, a good comparison of the results in this research are seen.

Table 5.1 shows all the correlations divided in four categories (weak, moderate, strong and no correlation or no significant correlation). The collected nine datasets organized in this table are based on their $\rho's$. Section A shows a moderate connection between students' initial attitude (CLASS pre) and their final conceptual understanding (FCIpost). In particular, it seems that the more positive pre students' attitude about physics, the greater their understanding of physics concepts. In the other way the lower students' attitude about physics causes lower of understanding physics concepts. Correlations 1, 2, 3, 4 and 6 in table 3.2 appear to be significant for section A. According to the data there is a general strong relationship between students' pre and post conceptual understanding for five sections (A,D,F,G and K).

As can be seen in table 5.1 there are significant and positive moderate correlations between students' incoming attitude with their final conceptual understanding, including sections (A, C, D, F and H). However, correlation 4, which measured the relation between students' income conceptual understanding and final attitudes, shows insignificant relation.

Interpretation of our study results and comparison with previous results (Adams and Perkins's correlations) are presented in table 5.2. We include the statistically

Table 5.1: Summarizing CLASS and FCIs' Correlations

Correlation	Weak	Moderate	Strong	No Signficant Correlation
Opre vs. FCIpre	A,F,H,K	C, D		E,G
Opre vs. FCIpost	E,K	A,C,D,F,H	-	E,G
Opre vs. FCIgain	A,F,G,K	H	-	C,D,E
FCIpre vs. Opost	A	-	-	C,D,F,G,H,K
Opost vs. FCIpost	F,H,K	-	C ,	A,D,G
FCIpre vs. FCIpost	C	E	A,D,F,G,H,K	
Oshift vs. FCIgain	C,E,F,G,H,K			A

significant correlations that can be easily seen and generalized. Note that sections C, D, E, and F are not shown here because they have small number of students in them. The trends are much easier to compare by omitting the above mentioned sections. Section G has a low post percentage with 44%, so we ignore any correlation that involve the post for section G. Also, the other two correlations were weak and not significant to be considered.

Table 5.2: Comparing $\rho's$, *ρ=0.053 when correlating Opost vs. FCIpost for section A

Variables	ρ (other)	ρ section A	ρ section H	ρ section K
Opre vs. FCIpre	.294	0.377	.321	.286
Opre vs. FCIgain	.21	0.339	-	-
Opost vs. FCIpost	.24	0.218*	-	-

5.1 Future Work

Based on some of the results, there is tremendous need for the future work in this area. One of the recommendations for the future work would be to conduct study on a larger scale with more number of sections, different teaching styles and different student attributes. Additionally, more variables would identify more accurate results that are easily comparable to the published results. They study can also be expanded to include a school for example school of engineering, or school of education, and study students' attitudes and interests towards each one of those. Nonetheless, there is much scope of expansion and improvement to such behavioral studies.

Chapter 6

Appendices

6.1 APPENDIX A: CLASS

The Colorado Learning Attitudes about Science Survey (CLASS) is a survey of attitudes and epistemological beliefs about physics, freely provided (http://www.colorado.edu/sei/class/) for educators to use and here is a copy of this Survey. Note, that the answers range from 1 (Strongly Disagree) to 5 (Strongly Agree).

Name:——————————

UID:——————————-

Introduction

Here are a number of statements that may or may not describe your beliefs about learning physics. You are asked to rate each statement by circling a number between 1 and 5 where the numbers mean the following:1 (Strongly Disagree) to 5 (Strongly Agree).

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, choose 3.

1. A significant problem in learning physics is being able to memorize all the information I need to know.

2. When I am solving a physics problem, I try to decide what would be a reasonable value for the answer.

3. I think about the physics I experience in everyday life.

4. It is useful for me to do lots and lots of problems when learning physics.

5. After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.

6. Knowledge in physics consists of many disconnected topics.

7. As physicists learn more, most physics ideas we use today are likely to be proven wrong.

8. When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values.

9. I find that reading the text in detail is a good way for me to learn physics.

10. There is usually only one correct approach to solving a physics problem.

11. I am not satisfied until I understand why something works the way it does.

12. I cannot learn physics if the teacher does not explain things well in class.

13. I do not expect physics equations to help my understanding of the ideas; they are just for doing calculations.

14. I study physics to learn knowledge that will be useful in my life outside of school.

15. If I get stuck on a physics problem my first try, I usually try to figure out a different way that works.

16. Nearly everyone is capable of understanding physics if they work at it.

17. Understanding physics basically means being able to recall something you've read or been shown.

18. There could be two different correct values to a physics problem if I use two different approaches.

19. To understand physics I discuss it with friends and other students.

20. I do not spend more than five minutes stuck on a physics problem before giving up or seeking help from someone else.

21. If I don't remember a particular equation needed to solve a problem on an exam, there's nothing much I can do (legally!) to come up with it.

22. If I want to apply a method used for solving one physics problem to another problem, the problems must involve very similar situation.

23. In doing a physics problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem.

24. In physics, it is important for me to make sense out of formulas before I can use them correctly.

25. I enjoy solving physics problems.

26. In physics, mathematical formulas express meaningful relationships among measurable quantities.

27. It is important for the government to approve new scientific ideas before they can be widely accepted.

28. Learning physics changes my ideas about how the world works.

29. To learn physics, I only need to memorize solutions to sample problems.

30. Reasoning skills used to understand physics can be helpful to me in my everyday life.

31. We use this statement to discard the survey of people who are not reading the questions. Please select agree-option 4 (not strongly agree) for this question to preserve your answers.

32. Spending a lot of time understanding where formulas come from is a waste

of time.

33. I find carefully analyzing only a few problems in detail is a good way for me to learn physics.

34. I can usually figure out a way to solve physics problems.

35. The subject of physics has little relation to what I experience in the real world.

36. There are times I solve a physics problem more than one way to help my understanding.

37. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.

38. It is possible to explain physics ideas without mathematical formulas.

39. When I solve a physics problem, I explicitly think about which physics ideas apply to the problem.

40. If I get stuck on a physics problem, there is no chance I'll figure it out on my own.

41. It is possible for physicists to carefully perform the same experiment and get two very different results that are both correct.

42. When studying physics, I relate the important information to what I already know rather than just memorizing it the way it is presented.

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