STUDENT ATTITUDES AND PERFORMANCE IN AN ONLINE

GENERAL EDUCATION PHYSICAL SCIENCE COURSE

by

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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ABSTRACT


PHYSICAL SCIENCE 100 ONLINE: STUDENT ATTITUDES

AND PERFORMANCE IN AN ONLINE LEARNING ENVIRONMENT


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A web-based version of a general education physical science course has been developed and implemented at Brigham Young University. Student attitudes, performance, and website interactions were measured during the initial pilot course in Spring 2000 and the second implementation which followed in Fall semester 2000. Control groups consisted of traditional lecture-based sections with enrollments exceeding 300 students. The web-based experimental sections had enrollments of 25 to 50 students.

Results of an analysis of the Fall 2000 data is presented here. Students did not use the web pages to the degree that was intended by course architects, thus limiting the effect that the online learning environment may have had on attitude and performance. There was no statistical difference in performance between control and experimental groups, however there were observed meaningful differences. There is no

evidence for self-selection among students in the web-based section. The web-based course was rated slightly lower by students than the traditional sections, an artifact of technical problems encountered early in the course. An analysis of learning style and orientation showed no correlation with gathered data, suggesting that the web-based course is suited for a wide variety of learning styles.

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# Chapter 1

# Introduction

## 1.1    Background

The Internet has revolutionized communication. It has prompted a number of studies into the "effectiveness" of the web as a tool for delivering and presenting course content[1]. Universities have been pondering how the Internet can benefit their programs and institutions[2]. A wide variety of online courses and course content exists. The virtual learning community is growing.

More than 300 studies have exhibited the so-called "No Significant Difference" (NSD) phenomenon[1] which is defined as no significant (statistical) difference in student performance between traditional and online distance-learning courses. A vast majority of these studies have investigated courses unrelated to the "hard sciences." A search by the author against an online index[3] of NSD studies returned only one article related to "physical", "science", or "physics". It is safe to say that the question of the effectiveness of web-delivered courses in the physical science is a largely unanswered one. However, there is little justification for believing that the case would be any different[1].

Other questions exist beyond those of student performance: are there certain types of students that are catered to with online formats? Are these types limited

to the technologically skilled elite? Are learning styles a factor? Russell[4] indicates that there is "no significant difference" between technologically delivered material and traditional methods. Russell qualifies his findings by suggesting that certain types of individuals may benefit (or be at a disadvantage) from web-delivered material and summarizes, "When lumping all the students together into a fictional mass, those who benefit from the technology are balanced by a like number who suffer; when combined with the 'no-significant-difference' majority, the conglomerate yields the widely reported no-significant-difference results."[4]

As there are few NSD papers regarding subjects in the physical sciences, there is a corresponding lack of questions into how online learning environments impact pedagogy and student understanding of basic principles and concepts. This is not a performance question, but a question of comprehension, attitude, and understanding. Some student misconceptions in physical science have been identified[5]. Does web-delivered content help students overcome these misconceptions better or worse than in a traditional, lecture-oriented course? How can a professor know? This thesis is a first attempt at answering some of these questions.

### 1.1.1   Current State of Physics Education

An examination of the American Journal of Physics (AJP) and The Physics Teacher (TPT) from 1975–present[6] showed no research in web-based physics courses as having been conducted. Indeed, the American Association of Physics Teachers (AAPT) has only published one Physics Education Research (PER) journal[7], and that in July of 2000. Articles and papers in the AJP and TPT focus on teaching methods, new lecture materials, demonstrations, etc. Few are *studies* into how these new materials and methods are impacting student attitudes and performance.

By contrast, the January 2000 national meeting of the AAPT had several papers presented about online learning environments in physics[8]. It is evident that studies into online physics classes is accelerating.

Traditional learning environments in physics have benefitted from a number of teaching methods and concepts that have appeared in the 1990's. "Just-in-Time Teaching"[9] attempts to mix Active Learning[10] concepts with web-delivered materials (not online courses). "Physics by Inquiry"[11] is a program where students learn physics concepts via question-based exercises rather than through lecture or memorization. "Peer Instruction"[12] gets students involved with each other in group-oriented exercises that are applicable to a wide range of learning environments. More of a program than a method, "Remodelling University Physics"[13] is an effort to structure classes and curriculum to meet the needs of cooperative learning environments while universities struggle with the pressure to "go online". The content for the online course studied in this thesis was developed with these paradigms in mind (see Section 1.2.2).

At the time this thesis was conceived and formulated for prospectus review, there was no published information on online physics education research. Thesis questions were formulated in this vacuum, and in hindsight the realization has come of which questions should have been asked initially. This research is formative in nature. Hopefully the interested reader will learn from our experience, and develop questions that lead to further insight about this important field of education research.

## 1.2  Course Description

### 1.2.1  Physical Science 100 - General Description

Physical Science 100 is a general education course intended for college freshmen who are pursuing non-science majors. Topics covered in the course include Classical Mechanics, Special Relativity, Chemistry, Nuclear Physics, Quantum Mechanics, Astronomy, and Geology. Each of these areas is covered by a conceptual treatment of the subject matter. With the exception of Newton's Second Law, the Universal Law of Gravitation and the Electric Force Law, there are no equations or advanced mathematics used. Student enrollment per semester averages 2,000 students across 10-15 sections. Small sections contain about 100 students - large sections are full at 330. Upon successful completion of the course, students receive 3.0 credit hours.

The course is presented in lecture format with a minor laboratory element. The intent is to provide the student with a conceptual framework in which further exploration and study is possible and to broaden student interests. There are four midterm exams, each corresponding to the four main units of the course (Physics, Chemistry, Astronomy, and Geology). These exams contain multiple choice and essay questions (with the exception of the fourth exam which is all multiple choice). The final exam is comprehensive. In addition to exams, students are required to complete one Special Activity per unit involving a "hands-on" exploration of a concept emphasized in a particular unit. Grades are based on the average scores of the four midterm exams and Special Activities, or the final exam score. The higher of the two is selected for the final grade. Students may also attempt to test out of the general education course requirement by taking an exemption exam similar to the final.

Professors teaching the course generally follow the course outline and schedule

as printed in the course syllabus (with the exception of the online section, discussed below). Exams are identical across sections and are administered through the University's Testing Center. Professors are provided experimental apparatus for demonstrations as well as video clips and a limited number of overhead transparencies (i.e. a periodic table of the elements or a Hertzsprung-Russell diagram). Professors bring their own lecture materials, consisting mostly of overhead transparencies with a few computer-based presentations being favored. Classes usually meet three times a week for 50 minutes, the exceptions being the night and online sections.

A walk-in help laboratory staffed by teaching assistants is available to all students enrolled in the course. TA's consist of students who have previously taken the course and who achieved higher than average performance. They are not physics majors, and include majors that cover a wide range of disciplines. The help laboratory is a first-come first serve open tutorial environment where students can get one-on-one help from a TA. Videos and other media are available in the lab for students to watch or review. TA's also handle the assignment and grading of the Special Activities and provide review sessions before midterm exams. At exam time, TA's grade the essay portion of the exams.

### 1.2.2   Online Variant of Physical Science 100

The intent of the online version of PS100 is to provide the student with a set of materials that allow increased flexibility and greater interaction with course materials. Flexibility is achieved by allowing students (in a given period of time - usually 1 week) to work at their own pace and location of choice. Interaction is developed through the use of various online interactive media such as Macromedia Flash and Shockwave objects, Quicktime video, etc..

At the heart of PS100 Online lie the course content web pages that were designed to be a replacement for lecture, not the text. Designers and authors began with this paradigm in mind, structuring the content in a manner that highlights principles and ideas that are commonly focused on in lecture-based sections. Various paradigms found in the Physics Education Research community (see Section 1.1.1) were used to structure interactive content. The pages were designed to be Active Learning based[14], discouraging passive involvement by students.

The level of interactivity is much higher with the online content than traditional lecture content. Quicktime Videos of professors performing key demonstrations are accessible by the students, and can be played as many times as the student deems necessary. Interactive animations allow students to manipulate conditions or predict outcomes of various physical phenomena. Questions in-line with the presentation materials that provide instantaneous feedback help students focus on key concepts and ideas.

It should be noted that PS100 online is not meant to be an Independent Study course. Participants must be part or full-time students attending the University, and not be Distance-Ed or Continuing-Ed patrons. As such, exams are administered only at certain times during the semester, and students must be able to come to campus to take them. An Independent Study version of PS100 Online was developed and is currently available though BYU's Continuing Education department[15].

Students are required to meet once or twice a week in a classroom setting. Once a week is required, in the sense that all college classes require attendance. The optional second meeting time is available for students to interact with the class TA and ask questions regarding their reading assignments and the end of chapter questions found in the text.

In order to keep students on task and prevent procrastination, graded Lesson Check-in assignments are due on a regular basis. These are located at the end of each online lesson and consist of questions regarding the content just studied. Until Winter Semester 2001, the questions consisted of short answer and multiple choice types with little in common with questions found on exams. In Winter 2001, new questions were implemented in order to bring the content into agreement with what students are expected to know for exams and evaluation.

A portal was provided for students to access course materials and communicate with the professor, TA's, and other students, namely Blackboard's CourseInfo product[16]. From this portal, students could access course pages that in turn would take them at the completion of a lesson to the lesson check-in assessments. Online assessments were handled by Question Mark's Perception software[17].

## 1.3 Overview of Study

### 1.3.1 Goals and Intents

The purpose of this research was to study the effectiveness of on-campus web-based learning compared to traditional instruction in Physical Science 100. The following activities were conducted to achieve this purpose:

- An evaluation of the impact an online offering has on common student misconceptions regarding basic physics principles

- A definition of criteria and methods important for longer, more rigorous studies in physics based courses

- An evaluation of web-based physical science instruction on the basis of accommodating various cognitive and intentional learning styles

- A comparison of student performance and attitudes in the web-based physical science sections to those in traditional classroom settings in light of differing learning styles

### 1.3.2   Subjects of Study

Subjects in this study consisted of students enrolled in Physical Science 100 during the Spring 2000 term and Fall 2000 semester. A maximum of three course sections were studied in each period due to logistical limitations. For the purposes of this study, student names and identifying marks, section numbers, and professor's names will remain anonymous. None of the surveys administered were required to be taken.

### 1.3.3   Limitations of Study

My intent was to evaluate how effective this type of course delivery is for the University. I did not focus on the following activities:

- Development of new course content

- Evaluation of other courses outside of Physical Science 100

- Determination of ideal class sizes for this type of delivery

- Analysis or tracking of costs regarding development, delivery or implementation of the course

- Study of the human resources requirements necessary to support such a course

- Determination of the long-term retention of material by the students

- Evaluation of the impact the course had on university computer labs and other physical resources

- Analysis of appropriate course delivery mechanisms (i.e. over the network, on CD-Rom, etc.)

- Evaluation of course organization (i.e. meeting times, chat-rooms, newsgroups, etc.)

- Determination of whether this type of course is best for continuing education (distance learning) or stand-alone (on campus) implementation

- Study of effective student-student and student-instructor interaction mechanisms

As this was the first implementation of this new course in the general education curriculum, many at the University were interested in studying it. This led to collaborations with other individuals on campus, most notably Greg Waddoups who was hired by the Center for Instructional Design to evaluate all online course offerings.

In order to not "survey the students to death" and minimize the impact this and other studies would have on the students, it was decided that instruments should not exceed ten minutes in length (about 20-30 questions) and that no more than three should be administered throughout the semester. Working under these guidelines, survey instruments were constructed that limited exploration and evaluation in areas of interest.

### 1.3.4 Formative vs. Summative

In every way this study is a *formative* evaluation of the PS100 Online course. This differs from a *summative* evaluation in that the course itself is still being developed. Caution is indicated in comparing the results of this study to other similar online courses that are well established (in terms of delivery technology, support, teacher familiarity, etc.)[18]. This study was done during a volatile stage of the course's development: the initial pilot stage, or beta testing if you will. Hence, much of the survey instrument content focused on student attitudes and perceptions, rather than specific physical science issues.

### 1.3.5   Spring 2000 vs. Fall 2000 studies

**Spring 2000**

The Spring 2000 term is a eight week session where classes are taught at roughly twice the normal rate. A 3.0 credit hour course taught during a normal semester meets for three hours a week in class, whereas the same course during the Spring term meets for six.

Spring 2000 was the very first time the course was taught. Two graduate students (one Ph.D. candidate and one M.S. candidate) taught and administered the course. As such, they had less experience in teaching but were perhaps more open and flexible to the paradigm of online teaching and courses. The class met twice a week for one hour (equivalent to once a week during a regular semester) in a discussion-type setting to review principles investigated online.

Surveys were administered at the beginning, middle, and end of the eight week period. These surveys were designed by Greg Waddoups and were not intended to be used rigorously. The intent of the Spring 2000 course was to lay the groundwork for the upcoming Fall 2000 implementation. Instructors, designers and evaluators focused on the changes that were necessary in order to allow for a broader application of the course for the Fall 2000 semester. Enrollment in Spring 2000 was limited to 30 individuals.

**Fall 2000**

The Fall 2000 course was taught by a full-time faculty member with extensive experience in teaching the traditional course. Using information collected by the previous graduate student instructors, the Fall 2000 course roughly followed the format of the Spring 2000 implementation. In addition to the once-a-week in class meeting,

a second hour was scheduled to accommodate an optional session available to those who felt a need for further instruction. This second hour was not lecture-based, but discussion oriented. Lesson-check in assignments were weighted less than during the Spring 2000 period.

Unfortunately, the Fall 2000 course was beset with technical problems from the outset that influenced the rest of the semester experience. Although problems were eventually overcome, the first two week struggle with technological and course delivery related problems caused great frustration among students and professor alike. This fact should be taken into account when the data is considered.

# Chapter 2

# Experimental Setup

## 2.1 Groups

### 2.1.1 Description of Control Groups

Control groups consisted of two sections of lecture-based Physical Science 100. Section 1 (as labelled in this study) met at 10:00 am Monday, Wednesday, and Friday (MWF) whereas Section 2 met at 1:00 pm MWF. Both sections were 50 minutes in duration and had experimental equipment on hand in order to support lecture material. Instructors were expected to teach one chapter a day following a syllabus prepared by the PS100 organizers. Other than experimental equipment and one or two overheads per lesson, instructors developed lecture materials themselves based on the information presented in the course textbook (see Section 1.2.1). Enrollments in both sections were at the maximum value of 330 students.

Access in traditional sections to online materials was not controlled and loosely monitored. A PS100 web page[19] is available to all students enrolled in PS100. This site contains links to other course materials, including the main content pages used by the semester online (Section 3) students. When accessed, these pages recorded logins as the "guest" user, although there is evidence in the log that instead of "guest", no ID was provided (see Section 3.7).

The PS100 organizers provided tests for both traditional sections. Each test consisted of 18 multiple choice questions and four essay questions, the latter being graded by student TA's employed by the Physics Department. All students were required to take the tests in the campus Testing Center. Tests were administered over a five day period in which students could go to the testing center when they chose (between 8am and 10pm).

Students in both sections were required to complete additional assignments called "Special Activities" which involved small experiments relating to a particular unit's subject matter. These activities were conducted outside of lecture and graded by the student TA's. One Special Activity was required per student per unit. Final course grades were assigned based on the raw score from each of the four midterms, the Special Activities scores, and final exam. If the average score on the midterms and Special Activities exceeded the final, the average score determined the final course grade, and vice versa. An additional 2 points of extra credit was available for the completion of an online university survey that was not part of this study. Table 2.1.1 provides a breakdown of points available in a traditional section.

| Exams 1,2,3 | 18 M/C q's; 4 essay q's | 2 pts ea., 8 pts ea. (68 pts/exam) |
|---|---|---|
| Exam 4 | 34 M/C q's | 2 pts ea. (68 pts) |
| Final Exam | 60 M/C q's; 8 essay q's; | 2 pts ea., 8 pts ea. (184 pts) |
| Special Activities | 4 Act. | 8 pts ea. (32 pts) |

Table 2.1: Grading scale for traditional sections.

## 2.1.2 Description of Experimental Group

The experimental group consisted of the entire Semester Online section (Section 3 in this study) of Physical Science 100. Lecture content was delivered in an online format and students were required to meet once a week in class. The semester schedule called

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for two days, 2:00–2:50 pm Tuesday and Thursday, however the instructor used one of the two days as an optional help session in which no new material was reviewed. In a given week, the required section (required in the sense that all college courses require attendance but no grade is given for attendance) covered the three chapters the students were assigned to complete. The purpose for the weekly meeting was to bring students together with the instructor so that difficult concepts could be reviewed and meaningful student-student and student-instructor interaction could occur. Experimental setups identical to those used in traditional lectures could be requested by the instructor and were often used.

For each weekly period (not necessarily corresponding to a Monday–Friday schedule) students were required to complete a "Lesson Check-in" after reading from the course textbook (same book as the traditional sections) and engaging in corresponding online materials. In the weekly period, three chapters were assigned. Students had access to future weekly assignments and could complete them early if so desired, but once a deadline had passed students were no longer able to receive credit. Online materials were always available regardless of due date, etc. Once a Lesson Check-in was completed, students were not able to access the questions until the day before the five-day period of midterm testing began. Lesson check-in points comprised about half the weight of one midterm exam if all were completed and these points were used in determining final grades.

Tests were identical to the traditional sections. Online students were also required to take their test in the campus Testing Center. Grading was done by the same TA's who graded the traditional section papers. Other than the student ID number, no other identifying information was given so TA's graded "blind" in terms of knowing which section a given student was in.

Online students were also required to complete the same Special Activities that traditional students did, with the same grade weight. Final grades were determined exactly the same as in the traditional sections (see above), with the exception of the additional points provided by the Lesson Check-ins. Thus, the total number of raw points was slightly higher for the online students than for the traditional section students.

Enrollment for the Semester Online section began at 76 students. After the add/drop deadline (two weeks after the first day of classes), 49 students remained registered in the course. Attrition is largely attributed to the fact that some students did not realize they had signed up for an online course, or that the course structure was not in keeping with what they perceived an "online" course should be.

## 2.2 Experimental Tools

### 2.2.1 Pre-survey

The Pre-survey consisted of 29 questions, eight of which were designed to catalog the level of student understanding of common misconceptions in physical science. Five questions queried the student on feelings and attitudes toward science in general, and another five measured skill in using varied computer and online technologies. Four questions covered student attitudes toward online technologies, two toward their attitude of online classes in general, and five questions on general expectations for the course. (See Appendix A for copy of the Pre-survey and other survey tools)

All Pre-surveys were administered on the first day of classes in paper format to all three sections (two control and one experimental). For Section 2, the surveys were administered at the beginning of class. Sections 1 and 3 were administered at the end. The Pre-survey took about 10–12 minutes to complete.

Student responses were recorded on separate answer sheets so that questionnaires could be used for the next section. Answer sheets were sorted by myself and then given to data entry personnel for entry into spreadsheet format.

### 2.2.2 Intentional Learning Orientation Questionnaire (ILOQ)

The Intentional Learning Orientation Questionnaire (ILOQ) is a diagnostic tool prepared by Margaret Martinez, et. al. for the purpose of quantifying a student's learning style. A description of the survey instrument and its intent can be found in Appendix C. The ILOQ was given during the week following the Unofficial Withdrawal (UW) deadline date.

The ILOQ was administered in paper format to the control groups and online via the CourseInfo[16] quiz engine to the experimental group. In the case of the online submissions, answers to individual questions were copied to answer sheets identical to those used in the paper based surveys and then submitted to the data entry personnel for entry into spreadsheet format.

### 2.2.3 Post-survey

Similar in format to the Pre-survey, the Post-survey consisted of questions geared toward measuring overall student attitudes and perceptions about the course as well as specific attitudes toward individual course components. Questions were designed with the online section in mind, but found broad applicability across sections with the exception of six questions that asked about specific components available only in the online content (which was available to the lecture section students — see Section 2.1.2). There were a total of 30 questions for the control group and 29 for the experimental group. The one question not given to the experimental group dealt with the number of hours per week spent accessing online course materials. This question

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was not given to the online students due to a formatting and publishing error, but similar information was available from another source (see Section 2.2.4).

The eight questions testing misconceptions were given verbatim from the Pre-survey, allowing for a repeated measures design. The Post-survey was administered during the final full week of classes in paper format to the control groups and in online format to the experimental group. In the case of the online submissions, a new software package allowed for student submission to be exported directly to spreadsheet format. The data entry personnel entered the answer sheets from the control groups by hand.

### 2.2.4 Other Tools

Aside from the formal survey tools, another type of data was collected. As students in the online course interacted with online question material, their answers were recorded in conjunction with user ID, time, date, lesson, and question information. Stored in a text log file, this allowed for statistics to be generated in regard to which students were fully engaged in using the online pages and those who were not. An ancillary intent of the data was to give teachers of the online course a source of information in regard to where students were at in terms of course material, and the level of understanding they are achieving by working with the online content.

## 2.3 Data Types

Inherent in the above discussion is the issue of data types. Falling into three main categories, they are: Affective, Performance, and Log.

### 2.3.1   Affective Data

Affective data is any data that relates to student perceptions, attitudes, and feelings about the course. This represents a majority of the data collected by the survey instruments. This type of data provides an educator with insight as to how the students perceive the course and are reacting to its design, implementation, etc. Though useful in general, this type of data is difficulty to quantify against any "absolute" scale.

### 2.3.2   Performance Data

Performance data is taken from student grades. In this study we are using percentage scores on all four midterms, the final exam, and the overall percentage grade (with special activities, extra credit, and Lesson Check-ins included).

### 2.3.3   Log Data

Log data was discussed above and provides frequency data on number of hits per student to the course content pages, as well as information on student understanding of the presented material.

### 2.3.4   Repeated Measures Concept Quiz

A concept quiz was included on both the Pre and Post-survey forms so that a repeated measures design could take place. The aim of this design was to identify and quantify a student's level of understanding related to several key concepts in Physical Science. The number of questions was limited to eight due to constraints discussed in Section 1.3.3. Questions covered concepts from Newtonian Mechanics to modern physics and were written by the author[1].

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[1] The Force Concept Inventory (FCI)[20] developed by David Hestenes, et. al. was not applicable in this situation as it did not cover the wide range of topics that are integrated into Physical Science 100.

### 2.3.5 Filetypes

The above data types were distilled into two different types of files. The first type contains all the information for each survey tool, i.e. the Pre-survey file contains all responses to the Pre-survey for all sections, etc. The second type is an amalgamation of all the survey tools across all sections (the master data file if you will). This file is filtered such that only those students who were assigned a final grade for the course had their responses to the surveys included. In other words, if a student dropped the class, their survey information was discarded. This file includes any data on any student who has grade information, so that if a student did not provide any survey information they are still included in this file.

## 2.4 Analysis Tools - Background and Uses

Rather than describe in detail the statistical methods and theory I have used in the investigation of the data, I will relate here some cursory background for those not familiar with statistical methods and tests. Please see the bibliography for other sources[21] of information regarding statistical analysis.

### 2.4.1 ANOVA

ANOVA stands for Analysis of Variance. Practically, ANOVA has the ability to discern if the results given for one group differ significantly from that of another. A "significant" result indicates that the difference in the means between two or more groups is not simply the result of chance alone. ANOVA can handle multiple groups, testing to see if differences exist among the possible combinations of the groups. ANOVA cannot tell you what or where the differences lie, but there are various a priori and post-hoc tests that can be employed to discover this information. MANOVA

stands for Multivariate Analysis of Variance, and as the name suggests is the method used when there are multiple dependent variables involved.

## 2.4.2 Correlation

Correlation is a measure of the relationship between two variables, and is related to Regression. If a correlation is significant, this means that the two variables correspond to one another in some way. The strength of this correlation is given in its r value, which can range from -1 to 1, 1 being the strongest correlation possible.

## 2.4.3 Statistical Significance vs. Meaningful Difference

A careful distinction must be made between data that is statistically significant and data which describes a meaningful difference. A statistical test may be significant (which definition depends on the test being used) but that does not necessarily mean that the result is meaningful. For example, there may be a statistically significant difference between the means of test scores between two different groups, but if the means are 95.5 and 95.9 on a 100-point scale respectively, these two results are not of practical import. Statistical significance relies on a variety of factors that are input into the mathematical routines. Meaningful difference relies on the scales used and the ultimate determination by the investigator of whether or not that difference is truly "different".

## 2.4.4 SPSS Software

SPSS[22] was used in all statistical analysis of the data. A statistical package used across multiple disciplines, it contains both basic and intermediate statistical tests and analyses.

# Chapter 3

# Results

The following are results from the various tools used during the course of this study. All graphs were produced in SPSS[22]. Please see Appendix B for descriptive statistics on each of the questions presented on a given survey tool.

As a reminder, section labels are as follows: Section 1 and Section 2 are traditional (lecture) courses and Section 3 is the Semester Online course. Section 1 was taught at 10:00 am MWF, Section 2 at 1:00 MWF, and Section 3 2:00 pm TTh, each for 50 minutes.

## 3.1 Graph Types

Three types of plots are utilized when data is presented in graphical form. These types are defined and explained below.

### 3.1.1 Error Bar Plots

Figure 3.1 is an example of an Error Bar plot. The mean of a variable is denoted with a small box which has extensions above and below. These extensions indicate the range of uncertainty a particular calculation of the mean has (in technical terms, this uncertainty is called the Standard Error of the Mean). Thus, the extensions are one Standard Error above and below the mean value. The Standard Error of the

Mean is related to the Standard Deviation in the following way:

$$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

where $\sigma$ is the standard deviation of the original distribution and N is the sample size. $\sigma_M$ is thus defined as the standard deviation of the sampling distributions of means[21]. Data on Error Bar plots can be thought of in this manner (referring to Figure 3.1 for an example): the average age for students in Section 1 is about 20.25 years, plus or minus 0.25 years.

### 3.1.2  Frequency or Bar Charts

Figure 3.2 is an example of a Frequency or Bar chart. Frequency charts indicate the number of times a particular variable is referenced. The higher the bar, the more times that variable occurred in the data. Figure 3.2 contains four different bars in three different groups. In this instance, the groups correspond to the three sections studied, and the four different bars represent the four different school year classifications a student can be in (i.e. Freshman, Sophomore, etc.). If there is only one bar, then only the variable on the x-axis is being referenced.

### 3.1.3  Box and Whisker Plots

Figure 3.9 is an example of a Box and Whisker plot (also called Boxplots). Box and Whisker plots are used to show the full range of values a particular variable takes on, and where a majority of occurrences of that variable lie. To understand how to read a plot of this type, the term "percentile" needs to be understood. A percentile is a measure of relative standing against all data points. If a score falls in the 25th percentile, this means that 25% of the total number of scores are below this value and 75% are above. A score in the 90th percentile would have 90% of the total number of

scores below and 10% of the total number of scores above it. Notice that percentiles refer to *the total number of scores* rather than the scores themselves.

The main box on a Box and Whisker plot starts at the 25th percentile and extends up to the 75th percentile. In other words, 50% of the total number of scores occur in the range marked by the box. The "Whiskers" indicate the minimum and maximum value that the scores obtained[1]. The line dividing the box sections (which sometimes falls on the top or bottom edge of the box) is the Median of the scores. The Median refers to the middle value of the scores, and should not be confused with the Mean or average value of the scores.

As an example, Figure 3.9 indicates that for Section 1, 50% of the students answered the survey questions with a 4, 5, or 6. The highest answer was a 7, and the lowest a 2. The middle value (*not* the average) was a 5. This can be compared with Section 3, where 50% of the students answered between 3 and 4, with answers as low as 1 and as high as 5.

## 3.2   Demographics

Figures 3.1 to 3.4 show demographic information of those who participated in surveys during the course of the study. Data was obtained from both Pre and Post-survey tools.

The mean age (Figure 3.1) for Section 2 was statistically lower than the other two sections (as determined by an ANOVA analysis) . For each section, Freshmen and Sophomores dominated the class (Figure 3.2). Figure 3.3 shows a slight predominance of female participants in all sections. All students regardless of section expected to receive an "A" or "B" grade in the course (see Figure 3.4).

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[1]Some statistical software packages have different definitions for whiskers on a Box and Whisker plot. In SPSS (used in all calculations for this study) whiskers indicate the highest and lowest scores
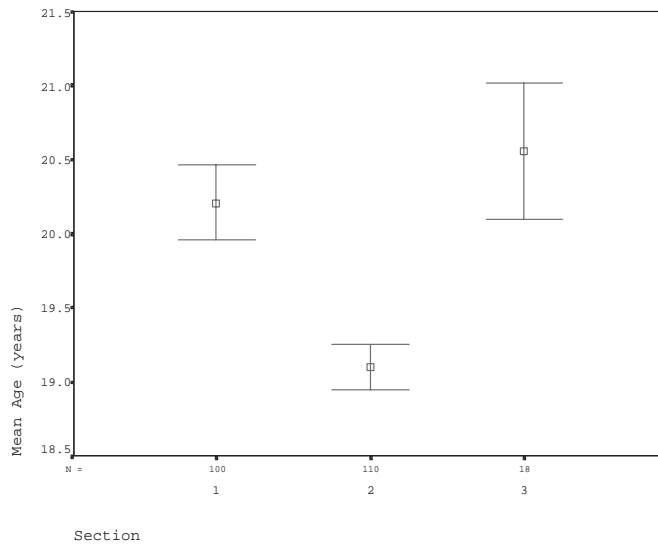
Figure 3.1: Mean age across sections of those surveyed (taken from Post-survey data). The average age for Section 2 is one year less than Sections 1 and 3. The large error bars on Section 3 are the result of the small sample size.
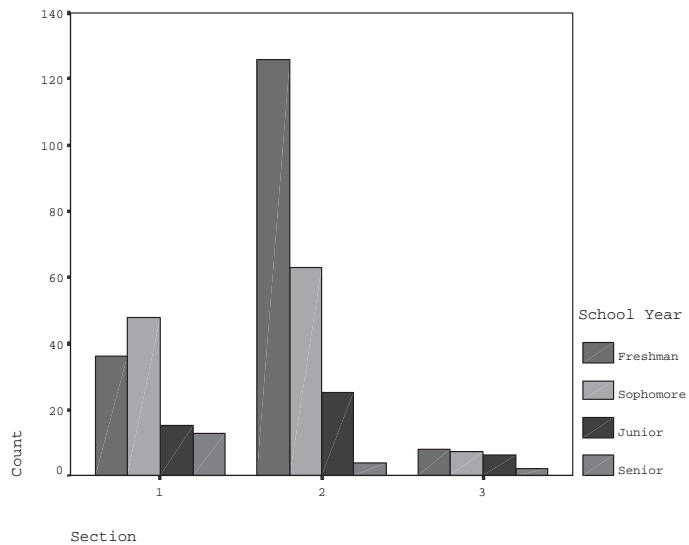


Figure 3.2: Year in school for all sections of those surveyed (1=Freshman, 4=Senior) taken from Pre-survey data. Freshmen dominate.
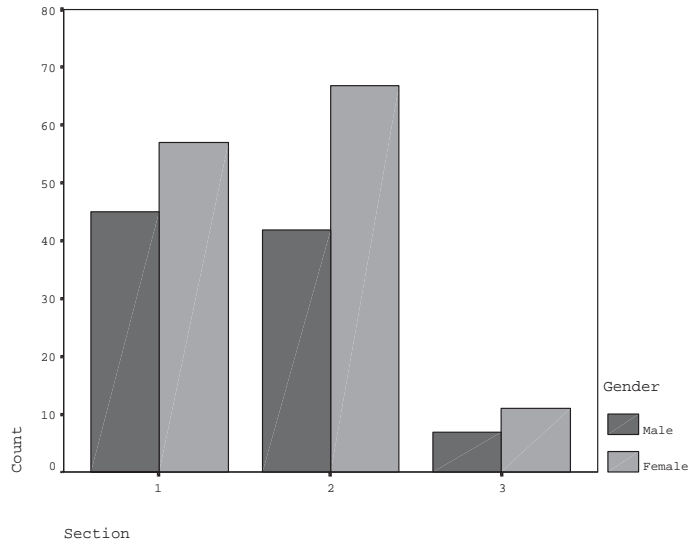
Figure 3.3: Gender across sections of those surveyed (take from Post-survey data). There are more females than males.
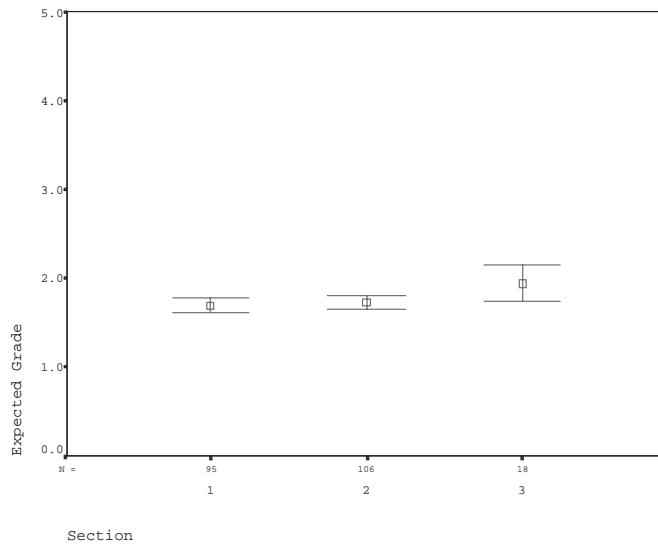


Figure 3.4: Mean expected grade across sections (1=A, 2=B, etc.). Data obtained from Pre-survey. All sections answered the same with the expected grade falling between an A and a B.

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## 3.3 Pre-survey

As mentioned in Chapter 2, the Pre-survey was administered on the first day of class. This was done so that the concept quiz questions could be asked in an environment that was not influenced by course content to which the students may have already been exposed. The problem encountered with the Pre-survey was students adding and dropping the various sections. The data gathered from the Pre-survey was checked so as to match section numbers for students that changed sections. This happened in only 3 cases. About 10% of the Pre-survey cases were discarded due to students dropping the course or switching to a section that was not being studied.

### 3.3.1 Technical Skill and Attitude

Students were asked to rank their skill and experience in working with offline and online technologies (1 being no experience and 7 being advanced experience) . For each student these scores were averaged into the Technical Skill variable. The mean value across sections did not significantly vary (see Figure 3.5).

Following the questions on technical skill, students were asked about their attitude toward working with online technologies and using computers (in general). Answers here were averaged into the Technical Attitude variable (1 showing strong disagreement with a given phrase and 7 indicating strong agreement). Again, there was no significant difference across sections (see Figure 3.6)

### 3.3.2 Attitude Toward Science

Students were presented with a series of statements regarding science in general and asked to indicated their level of agreement, 1 being strong disagreement and 7 being

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obtained *excluding* outliers (values that lie more than 1.5 box widths away from the median).
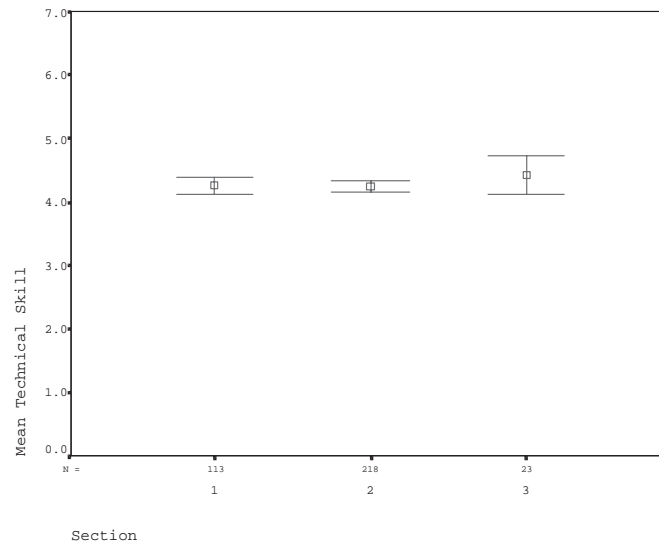
Figure 3.5: Mean Technical Skill score across sections. All sections averaged an answer of four on a seven point scale, midway between "Advanced" and "No Experience".
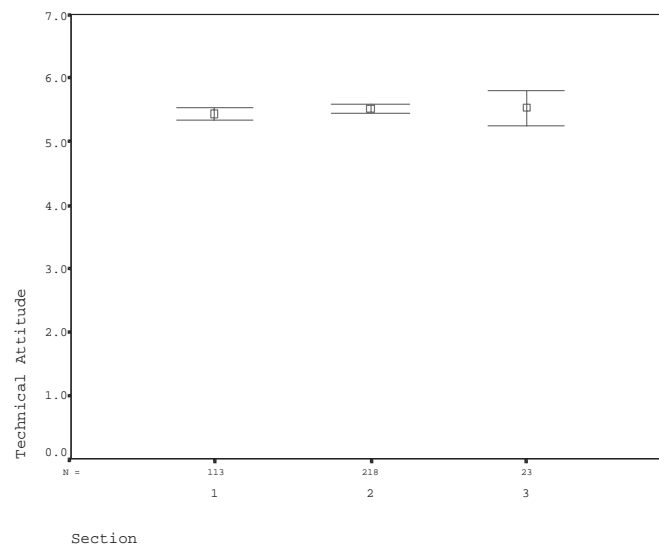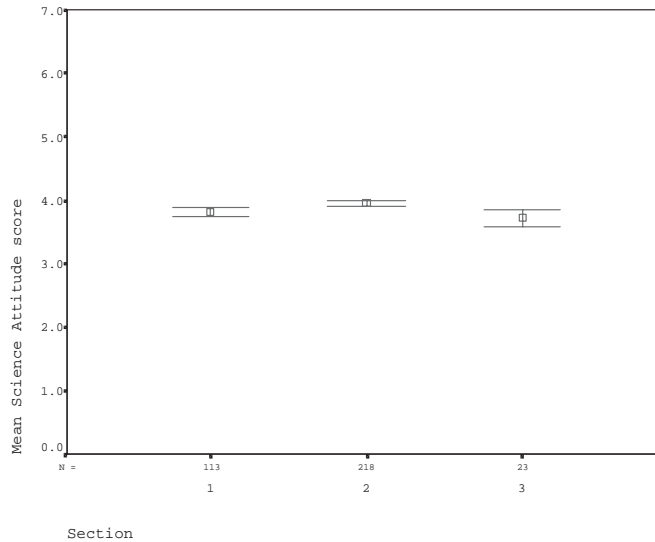


Figure 3.6: Mean Technical Attitude score across sections. A higher score indicates stronger agreement with question statements on a scale from one to seven. Generally, students in all three sections enjoyed using computers and web-based technologies.

strong agreement. For student subject these answers were averaged into the Science
Attitude variable, providing an index to overall attitude toward science. The mean
value across sections for this variable is graphed in Figure 3.7. There is no difference
across sections.



Figure 3.7: Mean Science Attitude score across sections. A higher score indicates
stronger agreement with question statements on a scale from one to seven. Generally,
students in all three sections were indifferent in their attitude toward science.

### 3.3.3 Specific Items of Interest

The following are analyses of specific questions contained in the Pre-survey.

**Question 15: "It is not necessary to be in a traditional classroom environment to learn."**

Figure 3.8 shows the mean value across sections for this question. Lower scores indicate disagreement with the given statement. Students showed weak agreement with this statement regardless of their respective section, meaning they felt that traditional instruction was not necessary for learning to occur. This data also highlights the difference between a statistically significant result and a meaningful difference result.

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Statistically, the mean value for Section 1 is different and lower than Sections 2 and 3 (which do not differ from one another). However, it is obvious that this difference is not significant in the fact that each mean is basically equal to an answer of five on the seven-point scale.

**Question 16: "I believe computer-based training via the web is not as effective as traditional training."**

As can be seen from figure 3.9, students in the Semester Online section (Section 3) showed stronger disagreement with this statement than students in the traditional sections, meaning those students in the online section were more apt to believe that computer-based training is as effective as traditional learning environments . However the difference, though statistically significant, is not very strong.

**Question 19: "My feelings toward online courses could be characterized as: 1) Apprehensive, 2) Indifferent, 3) Confident, 4) Very Confident."**

In both of the traditional sections no single student answered "Very Confident" to this question (see figure 3.10). Section 3 contained the full range of answers, with the mean falling along the "Indifferent" value. Figure 3.11 shows a frequency plot of answers for Section 3 only. "Apprehensive" and "Indifferent" answers predominate.
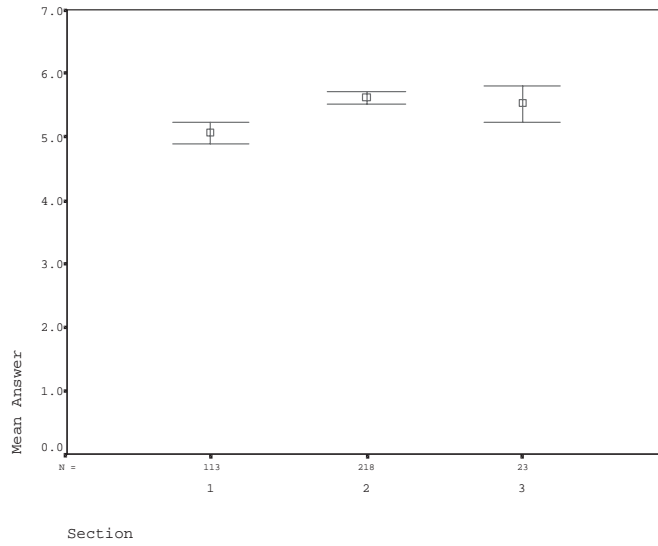
Figure 3.8: Mean answer across sections for Pre-survey question 15. Lower score indicates disagreement with question statement. Students in all sections felt that traditional instruction was not necessary for learning to occur.
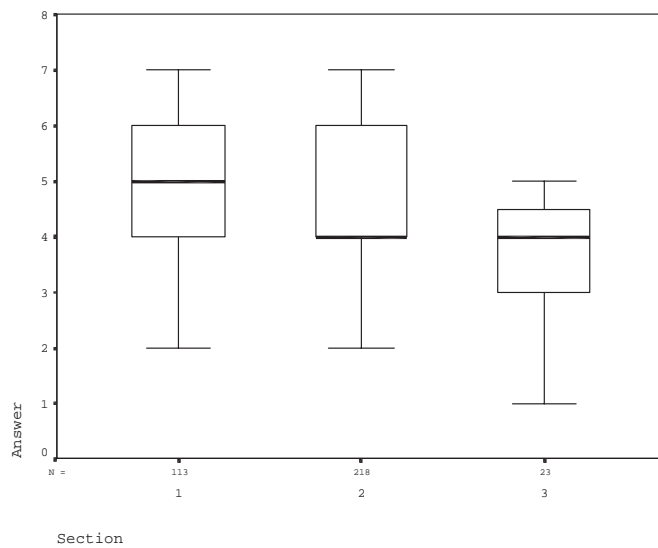


Figure 3.9: Mean answer across sections for Pre-Survey question 16. Lower score indicates disagreement with question statement. Section 3 students had a stronger belief that computer-based training is as effective as traditional learning environments.
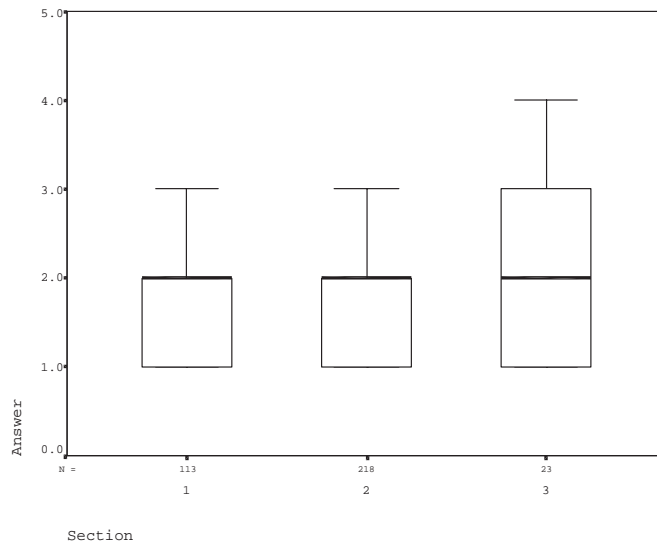
Figure 3.10: Mean answer across sections for Pre-Survey question 19. Students in Sections 1 and 2 felt more apprehensive about online courses than students in Section 3. Note that responses from Section 3 contain the full range of answers to the question whereas Sections 1 and 2 do not.
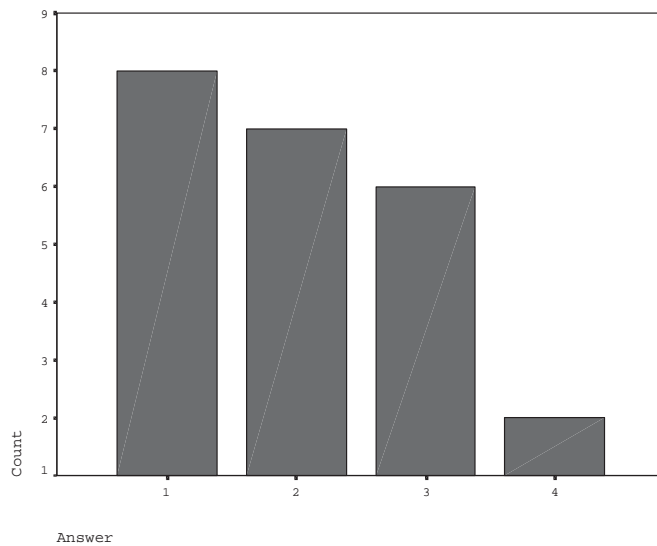


Figure 3.11: Detail of answers from Section 3 for Pre-survey question number 19. Most answers are in the "Apprehensive" and "Indifferent" categories.

## 3.4 ILOQ

Significant correlations were found with score on the ILOQ and the variables listed in table 3.1. Note that while significant, the correlations are very weak. In other words, though statistically related the relationship of these variables to a given ILOQ score is tenuous.

| Variable | Sig. | Correlation |
| --- | --- | --- |
| Midterm1 | 0.02 | 0.131 |
| Final Exam (%) | 0.026 | 0.125 |
| Final Grade (%) | 0.025 | 0.126 |
| Science Attitude | 0.023 | -0.166 |
| Course Attitude | 0.009 | 0.200 |
| Instructor Effectiveness | 0.049 | 0.151 |
| Course Quality | 0.028 | 0.168 |
| Amount Learned | 0.001 | 0.244 |

Table 3.1: Table of significant correlations with ILOQ score. While statistically significant, the correlations are very weak.

## 3.5 Post-survey

The Post-survey (see Appendix A) proved to have one challenge: low subject count. Administered during the last week of classes, there were fewer students participating than in the Pre-survey and ILOQ survey.

### 3.5.1 Overall Course and Instructor Ratings

The first three questions on the Post-survey asked students to rank overall aspects of the course. Rankings were based on a scale from one to seven, one being "Excellent" and seven being "Very Poor".

**Instructor's Overall Teaching Effectiveness**

When asked to rate the instructor's overall teaching effectiveness, students in Section 2 ranked their instructor one full point higher than students in Sections 1 and 3 ranked theirs (see Figure 3.12). Each section did have different teachers. Section 2 was also taught at 1:00 pm.

**Overall Course Quality**

In a similar type of question to that above, students were asked to rate the overall course quality (see Figure 3.13). Students in the Semester Online section (Section 3) ranked their course almost a full point lower on average than students in section 2. Section 1 fell between the other two sections. While statistically significant, the scores are still high and within one point of each other. A score of 4 is the midpoint between "Excellent" and "Very Poor".

**Amount Learned in Course**

A student's perception of the amount learned in a course is influenced by a plethora of variables. Nonetheless, students in each section rated the amount learned almost identically. With a mean of 4.75 (plus or minus 0.2) on the seven-point scale it is evident that all students perceived the amount learned to be something between "Very Little" (1) to "A Great Deal" (7), regardless of section.

### 3.5.2 Course Attitude

Questions four through thirteen of the Post-survey presented the students with specific statements about the course, from which they were asked to indicate their agreement on a seven-point scale. Answers for each student subject were then averaged to produce an index variable called Course Attitude. Subsequent analysis showed there
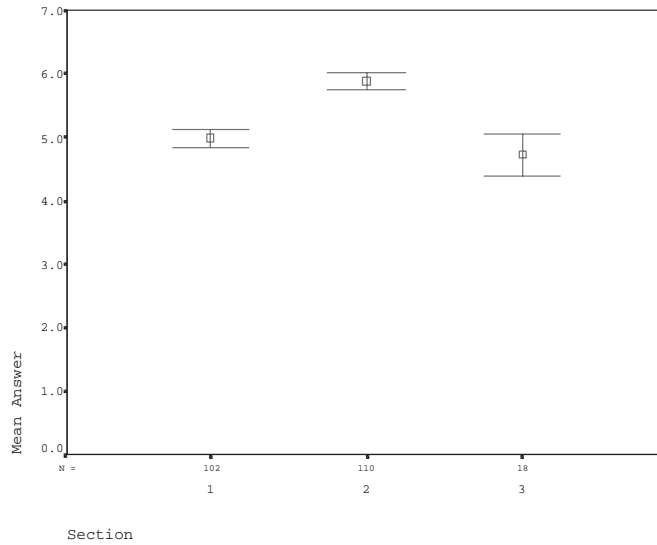
Figure 3.12: Mean score across sections for instructor's overall teaching effectiveness. Higher scores correspond to greater perceived effectiveness, with Section 2 students rating their instructor significantly higher than the other two.
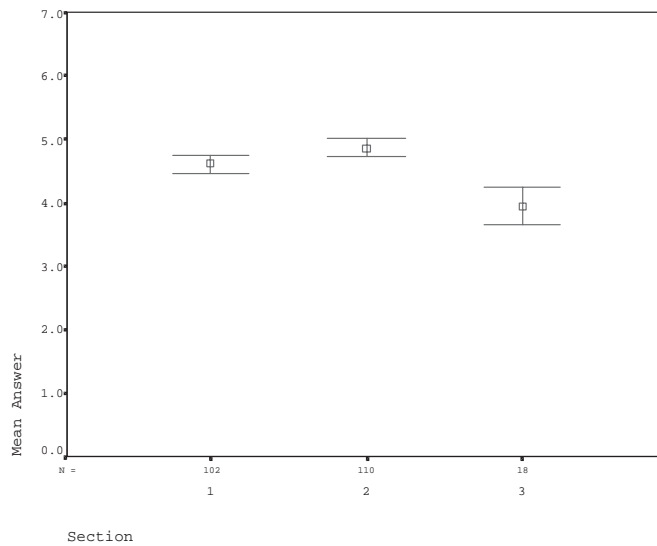


Figure 3.13: Mean score across sections for overall course quality. Higher scores correspond to greater perceived quality. Online students (Section 3) rated the course lower than the traditional sections, perhaps due to technical problems that influenced student perceptions.

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to be no significant difference in the responses across the three sections. Analysis of individual questions showed further than there were no differences across sections either. For the composite Course Attitude variable Section 1 and 2 shared a mean of 4.6, whereas the mean for Section 3 was 4.4.

### 3.5.3  Instructional Activities

Figures 3.14 through 3.20 correspond to questions that were tailored to the Semester Online section of students, though students from all sections answered these questions. Each question consisted of a particular course activity and students were asked to rate each one based on the following scale: "Very Ineffective", "Ineffective", "Somewhat Effective", "Effective", "Very Effective", and "Did Not Use". For computational purposes, each of these responses was assigned a number, 1 being "Very Ineffective" and 6 being "Did Not Use". See the figure captions for explanations regarding the data. Responses to these questions are presented only for Section 3.
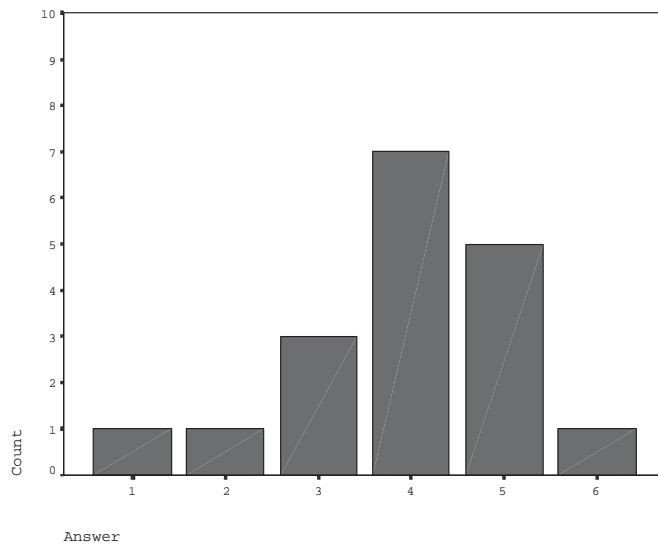


Figure 3.14: Effectiveness score for viewing videos embedded in the course. A majority of students rated the video content as "Effective" to "Very Effective".
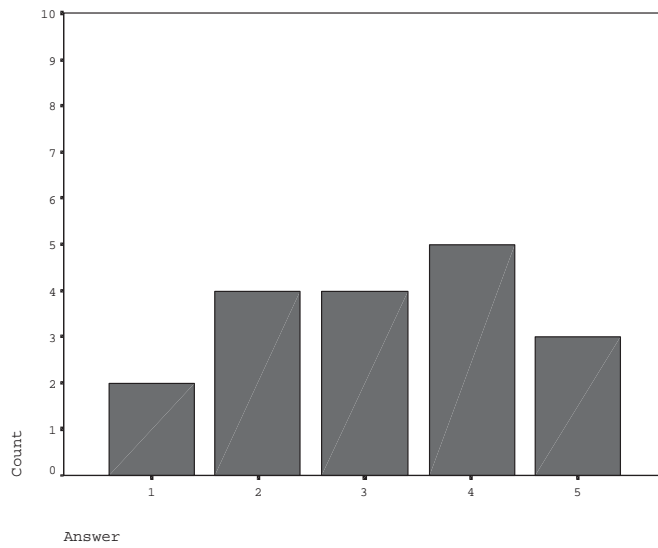
Figure 3.15: Effectiveness score for Lesson Check-in questions. There is disagreement among student ratings, indicating that Lesson Check-in questions are neither effective or ineffective.
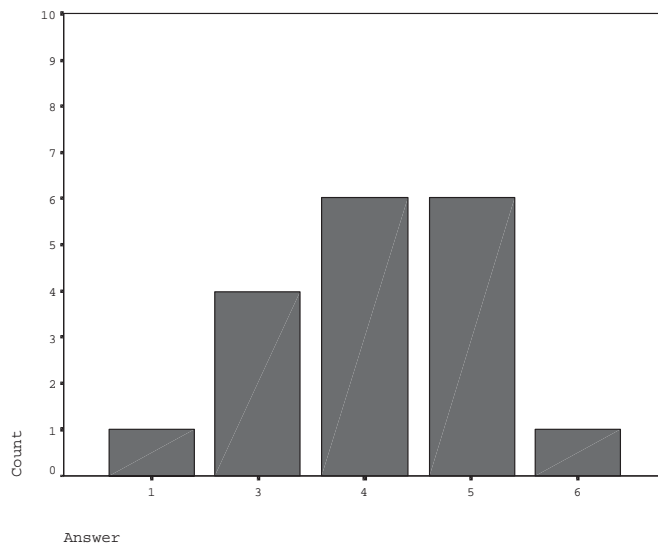


Figure 3.16: Effectiveness score for animations in the course. A majority of students thought the animations were effective.
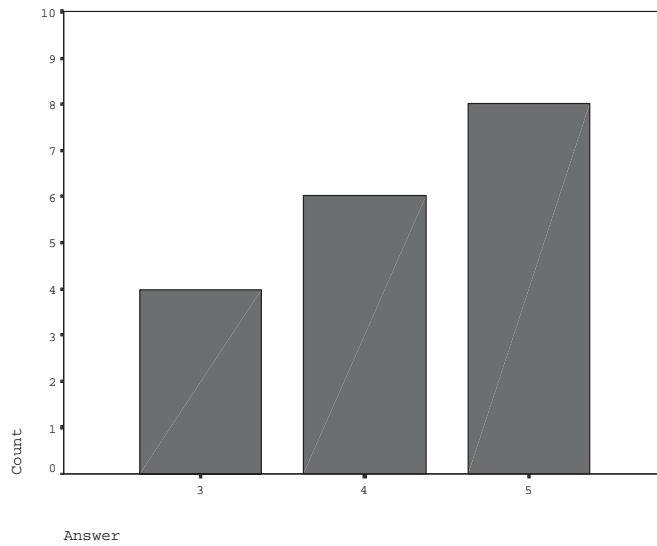
Figure 3.17: Effectiveness score for the textbook reading assignments. A majority of students felt that the textbook was "Effective" to "Very Effective".
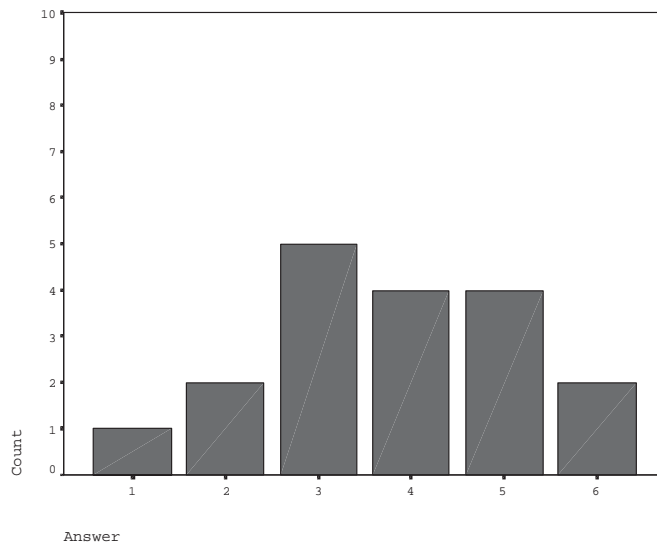


Figure 3.18: Effectiveness score for question feedback involving multimedia components. There was no clear consensus on the multimedia feedback, perhaps in part to the lack of multimedia feedback implemented during the Fall 2000 semester.
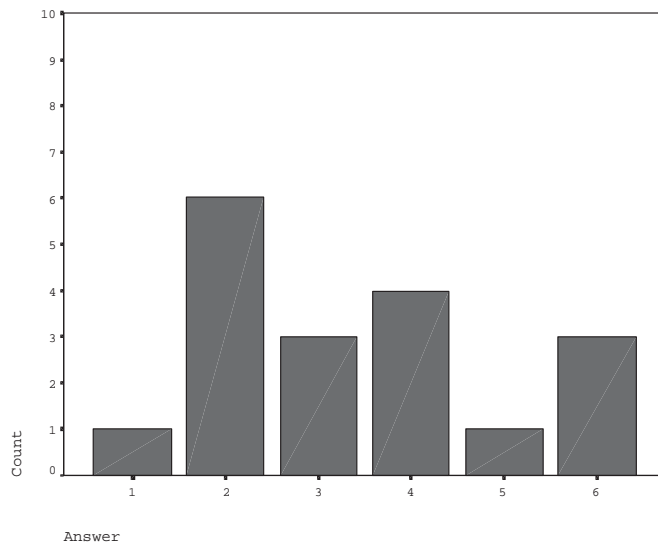
Figure 3.19: Effectiveness score for small group activities. Used only occasionally during the in-class meeting times, small group activities were not favored by the students.
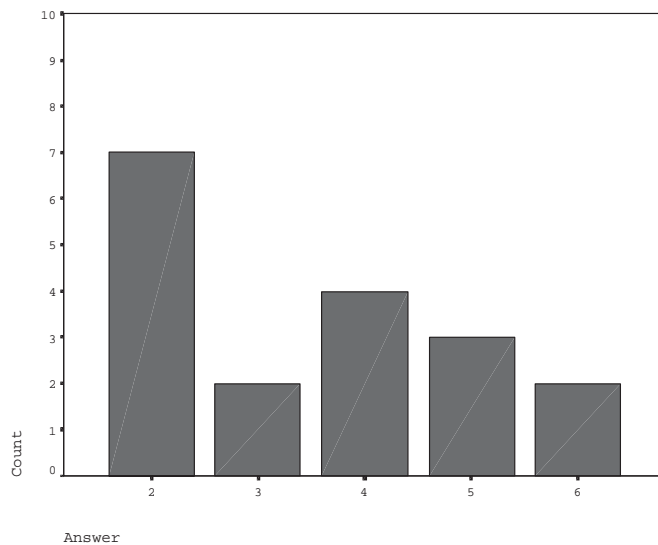


Figure 3.20: Effectiveness score for class meeting times. A large percent of students felt that the class meeting times were ineffective.

## 3.6  Concept Quiz Repeated Measures

In the previous sections detailing the Pre and Post-survey results I have omitted data on the concept quizzes. This data is now presented by discussing individual results from the Pre and Post-surveys, as well as the repeated measures analysis.

### 3.6.1  Pre-survey Concept Quiz

There was no difference in scores on this quiz across sections, with each sectional mean near a score of 3.75 out of 8 questions answered correctly. Surprisingly, students performed better on questions relating to modern physics concepts than Newtonian concepts. The reasons for this may be manyfold, but one possible explanation is the media's focus on modern physics when news of a scientific nature is presented.

### 3.6.2  Post-survey Concept Quiz

Again, there was no difference between sections for score on the Post-survey concept quiz. Students again performed better on questions regarding modern physics concepts.

### 3.6.3  Repeated Measures

A highly significant difference was found between the pre and post concept quiz scores across all sections. In other words, there was no difference in score between sections, but a difference in performance before and after being exposed to the course content. Average score increased for all sections by almost two points (the equivalent of answering two more questions correctly than on the pre concept quiz). See Figure 3.21.
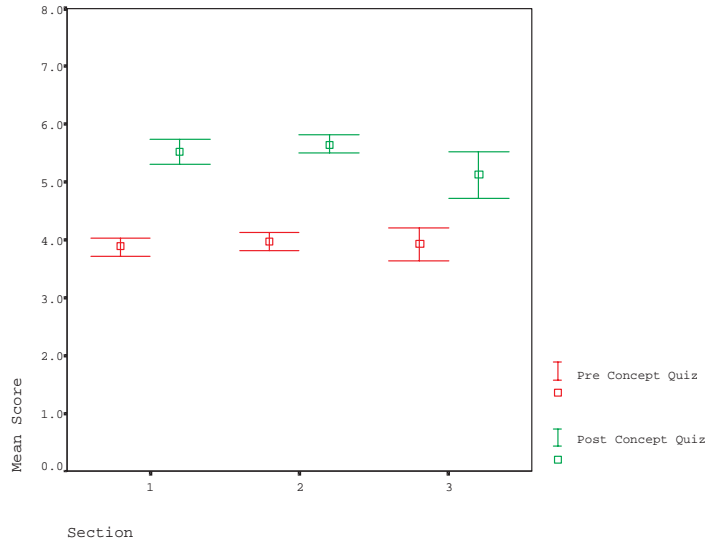
Figure 3.21: Repeated Measures for Pre and Post-survey concept quizzes. Higher score indicates better performance. There is a difference between pre and post scores for all sections, but sections did not score significantly different from one another.

## 3.7   Student Use of Web Content

Using data obtained from log files, the number of "interactions" a student had with the lecture-content web pages was available. An "interaction" is defined as any event where the student submits information in the form of an answer to a multiple-choice or free response question from the lecture-content pages, not the Lesson Check-in questions. The submission is logged to a text file with time, date, user ID, question, answer, lesson, and webpage information. Using a parsing program developed by the author, the logfile is converted into an Excel-friendly comma delimited text file. In SPSS, the number of interactions per user is determined by a frequency analysis. This information shows up as the "hitdata" variable.

Table 3.7 summarizes the correlation between the number of interactions a student has and grades for exams and for the course. These are the strongest correlations to be found in the entire study, and the message is clear: students who used the

| Variable | Sig. | Correlation |
|----------|------|-------------|
| Midterm 2 | 0.025 | 0.378 |
| Midterm 3 | 0.013 | 0.414 |
| Midterm 4 | 0.005 | 0.485 |
| Final Exam | 0.007 | 0.446 |
| Final Grade | 0.002 | 0.497 |

Table 3.2: Correlation results for web page interactions and student performance on exams and for the course. The correlations show a tendency for students to perform better in the course if the web content is used.
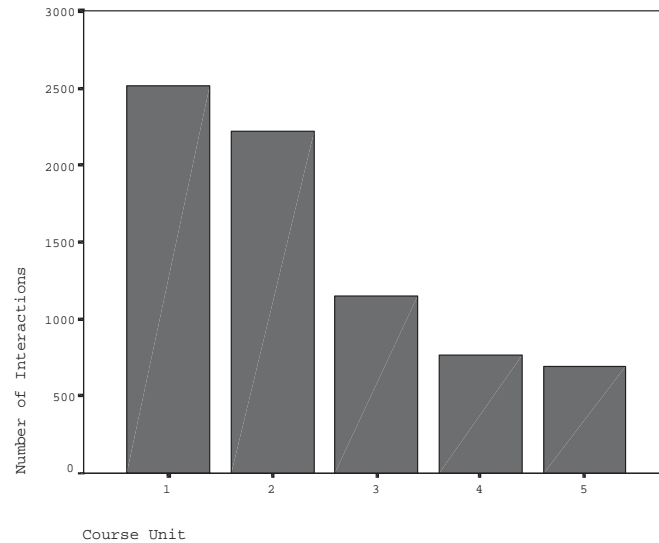


Figure 3.22: Students interact less and less with the course web-pages with each new course unit. Units 1-4 correspond to actual subject units, whereas unit 5 covers the one week period following the last midterm exam and the final exam. Each subject unit is about 3.5 weeks long.

web pages performed better than those who did not. This in and of itself is not a surprising result, especially when considering the analog for the traditional sections: if students attend lecture, they are likely to perform better in the course. What is shown here is that the web pages are not hindering student performance.

The number of interactions recorded during each of the course subject units is graphed in Figure 3.22. Students used the web pages with more frequency during the first half of the course (units 1 and 2) than during the last half (units 3 and 4). The number of interactions during the one week period of unit 5 (the time between the last midterm and the final exam) is almost equal to that of unit 4 (the last of the 3.5-week units covering Geology).
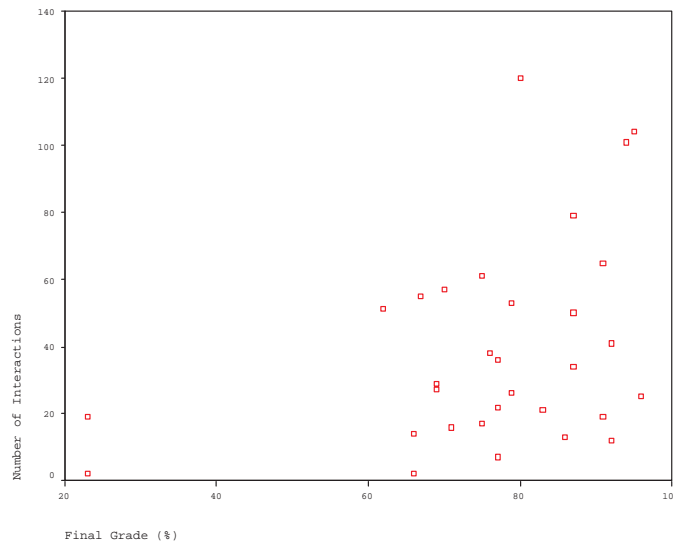


Figure 3.23: Students with high numbers of interactions (more than 70) did not receive a grade lower than 80%, whereas students with low numbers of interactions attain scores throughout the range, indicating that the online content does not hinder student performance.

Figure 3.23 is a scatter plot of student grades vs. the number of interactions a student had for the duration of the course. The most notable feature of the plot is that students with high numbers of interactions (more than 70) do not score lower

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than 80% overall. Students with low numbers of interactions cover the entire range of represented grades. This data indicates that students who use the online pages are not negatively affected in terms of performance. Also, students don't have to use the course pages in order to do well in the course, however a low grade is never coupled with a high interaction count.

## 3.8   Summary

I have endeavored in this section to explain the more significant results that can be obtained from the data collected. The reader is encouraged to see Appendix B which contains descriptive statistics for each question asked on all three surveys. I have attempted to refrain from commenting on the meaning and conclusions that can be drawn from the results, saving that discussion for the next chapter.

# Chapter 4

# Conclusions

One must always be wary of drawing hard and fast conclusions from data and results that rely heavily on statistical measure. As an example, the world of politics is rife with the abuse and misrepresentation of statistical data [23]. Seemingly, anyone who can reference some sort of "study" is able to woo the careless observer.

Human beings are perhaps the worst kind of research subject when it comes to statistical analysis. Endowed with free will and the ability to decide on action when faced with stimulus, humans resist any kind of quantification. In addition, scales used for ranking or judging items take on different meanings from subject to subject. In other words, a "7" for one individual may hold a different meaning than a "7" for someone else. Our life experiences heavily influence our objectivity[24].

Beyond these issues are those that deal in working with volunteers. If a reward can be obtained for supplying information, then those who would not normally be willing to participate are found at the front of the line. The converse is true as well, and I have direct evidence of this phenomenon among students in Physical Science 100 online at Brigham Young University. Candy bars delivered to the students upon successful completion of the Post-survey more than doubled the number of survey returns.

In light of these and other issues surrounding the use of statistics in investigating human subjects, I wish to make this comment: statistics help in the analysis of data and the investigation of the subjects at hand, but great care must be taken if generalizations are to remain valid. Indeed, I will refrain from such generalizations and focus on conclusions that can be drawn about the students who participated in Physical Science 100 during Fall Semester of 2000 at Brigham Young University.

## 4.1 Student Performance

### 4.1.1 Grades Across Sections

Grades across the sections did not vary significantly from one another. Indeed, students who took the online course were not significantly affected even with the abundance of technical difficulties and other frustrations that the course was plagued with in the beginning. Figure 4.1.1 is a plot of percentage scores on midterms for all three sections. Scores on the last two midterms dropped for the online section, a phenomenon that may be explained by the drop-off in student attendance during the second half of the semester. Also, the number of student interactions with the web pages dropped off after the second midterm. This may be due to the content presented in the second half of the course: students may feel they are more familiar with Chemistry and Geology and thus do not take these sections as seriously in their studies as the Physics content presented in the first half of the course.

Final exam and final course grades (see Figure 4.1.1) show the online students scoring lower on average in both categories, but only by two to three percentage points. Again, this is not significant, statistically or otherwise.
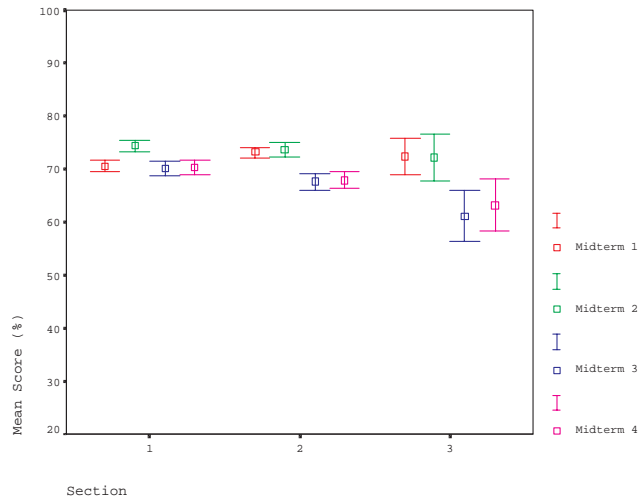
Figure 4.1: Percentage scores on all four midterm exams for each of the three sections. There is no statistical difference in the scores across sections.
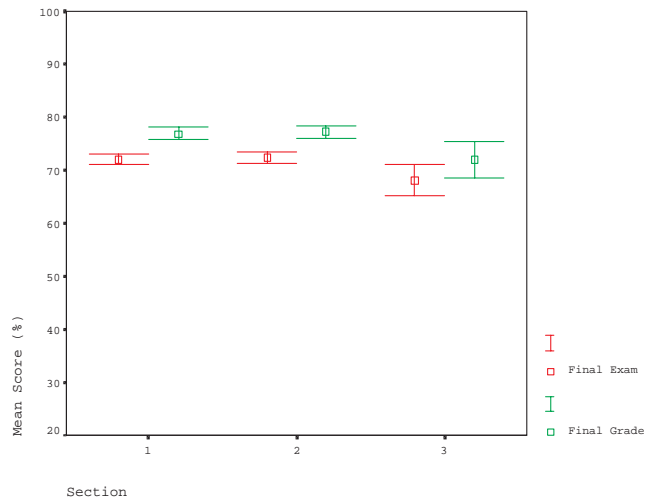


Figure 4.2: Percentage scores on the final exam and overall final course grade for each of the three sections. Again, there is no difference between sections.

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### 4.1.2 Performance Among Online Students

There is a significant dropout rate in the online course. Enrollment on the first day of class was about 79. By the add/drop deadline, the class had 49 registered. Of those, 10 were "ghosts" in the sense that no work was recorded and a final grade of "UW" (Unofficial Withdrawal) was assigned. By comparison, the two traditional sections had full enrollments of 330 through the add/drop deadline, with approximately 200-250 attending lecture on a regular basis. Out of 330 enrolled in one section, about 10–15 were given "UW" grades.

As was discussed in Section 3.7, students in Section 3 who used the online materials performed significantly better than those who did not. Midterm 1 was the exception, not showing any significant correlation. The data presented in Section 3.7 also showed a significant correlation between content interactions and final course grade.

### 4.1.3 Use of the Online Content in General

The highest recorded number of interactions for a given student was 120. This means that this particular student submitted 120 answers to questions found in the lecture-content materials *during the entire duration of the course.* With an average of about 10 possible interactions per lesson (some have 15–20, others 2–6), this could mean that only 12 lessons were covered by this student. Another possibility is that about four interactions took place per lesson across the 34 online lessons available.

The next highest number of interactions is 104, then 101, then 79. The mean number of interactions is 34.74 with a standard deviation of 31.03. In other words, there was an incredible range of interactions with a very low average amount. Discarded from this data is approximately 6,000 records, all of which had no user ID associated with the entry. The reason for this high number of blank entries may be twofold:

1) students in the traditional sections had access to the online lecture content pages through a special log-on with "guest" privileges which may have used the blank user ID, and 2) Students in the online course may have noticed that when logging in to the lecture-content pages that the user ID's were not checked, and therefore simply hitting the "submit" button sufficed. Students were reminded halfway through the course about using their user ID's when logging in, and following that announcement there was no change in the number of interactions. The problem inherent in the second item has been resolved for the Winter 2001 implementation of the course.

Assuming the data on interactions is correct, it is obvious that students in the Semester Online course are not utilizing a key component of the course. It can be argued that a similar effect is occurring in the lecture sections as well: of the 330 enrolled, only 200-250 attend, and the other 90-130 are not utilizing a key component of the course. Even if this is the case, the percentage of the online students who are not using lecture content is much larger than those in the lecture sections (83% vs. 32%).

## 4.1.4   Student Drop Out Rates

The results presented above in regard to final course grades were derived from data sets that had all UW's removed from all sections. Figure 4.1.4 is a bar chart indicating the relative percent of grade type per section. Final course grades were categorized as follows: 1 = UW, 2 = E, 3 = D, 4 = C, 5 = B, 6 = A. The percent values are calculated from individual section totals, and the separate colors correspond to separate sections. There were far more UW grades in the online section (by percent) than in the traditional sections.
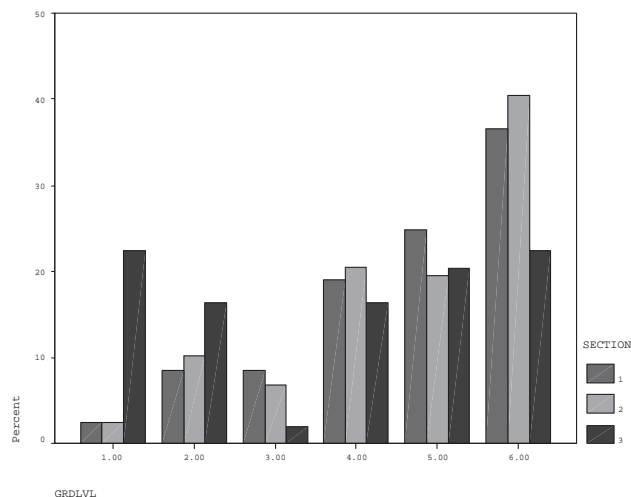
Figure 4.3: Each grade classification contains data for each of the three sections. Grade classifications are as follows: 1 = UW, 2 = E, 3 = D, 4 = C, 5 = B, 6 = A. The Y-axis represents the percent of the total number of grades in each section. The online section (Section 3) has a much higher percent of UW grades than the traditional sections, indicating a high dropout rate.

**Possible Reasons for UW Grades**

There may be many reasons for the high instance of UW's. Initial student reaction to the course was evenly divided between those who knew that the course was online, and those who did not. This may account for the large drop in enrollment prior to the add/drop deadline[1], but this alone does not explain the data shown in Figure 4.1.4.

On more than one occasion just prior to the first exam I observed students approach the teacher and remark, "I haven't been able to get to the online content. What should I do?" In each case, the student had not taken any action to contact the teacher, TA, or technical support personnel. For these students, the failure of the technology was an excuse to not participate rather than take advantage of the alternate learning opportunities available. Once behind, it is nearly impossible to

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[1]This data was not presented, but initial enrollment was at 76 students, then fell to 49 after the add/drop deadline.

continue with the course as new concepts build on old ones.

Of the eleven UW's total in the online course, 4-5 of these students were never seen or made contact with the course. No tests were taken, no lectures attended, and there is no record of them ever having used the course web pages. This is most likely due to registration misunderstandings from distance-learning students. Following the submission of final grades, there were five requests for grade changes from UW to W (unofficial withdrawal vs. withdrawal, the first being equivalent to a failing grade) due to registration errors and misunderstanding. It appears that of the eleven total withdrawals, only 6 may have root causes associated with the course itself.

An analysis of the individuals who were given UW grades shows no difference between Natural Science ACT score from students who successfully completed the course. There is no evidence to suggest that those who did not complete the course struggled with the content or ideas. From observation, I believe that the legitimate UW's (those who did not have registration problems) were the result of student procrastination and/or an artifact of technological difficulties encountered during the course.

### 4.1.5 Summary of Student Performance

Students who took the Semester Online course did not do any better or worse (statistically) than students in traditional lecture courses in terms of midterm, final exam, and final course grades. Dropout rates were much higher for the Semester Online course than the traditional course. For the most part, students in the online section did not use lecture-based content to the degree that students in the traditional sections attended lecture.

## Comments on Student Performance

Having said that, I must comment on student performance from the point of view of a teacher, rather than a statistician. In all data related to performance (grades, pre and post concept quizzes, midterm exams, final exams, etc.) the online student scores are lower on average. This is an item of meaningful difference rather than statistical significance (see Section 2.4.3). As an example, the final grade for the online students was four points lower than the traditional sections. This may be due to low sample size compared to the other sections, but may be indicative of other phenomena such as course organization, philosophy, and implementation.

I have often observed teachers of PS100 become emotional as they talk about the wonders, beauties, and mysteries of the physical universe. This emotion ranges from hyperactive excitement to stirring and reverent appreciation. Though not utterly lacking in the online course, these emotional connections are not made nor conveyed. Though there may be no statistical data to support the following fact, I believe it be true nonetheless: better teachers produce better students. An engaging personality engenders participation[25], and though there are always students who will not respond to such a personality, the majority can be affected for the better. The converse is true, and in my judgement the online course tends in the direction of the latter.

I found students to be more frustrated with the course as a whole, and with only one or two exceptions I doubt that they took away any appreciation for the physical sciences. Though this is an attitudinal observation, I believe that attitude has a significant impact on a student's willingness, if not ability, to perform.

## 4.2 Student Attitudes

From the information presented in Chapter 3, it is evident that there was no difference in student attitudes across sections, with the exception of overall course quality. Attitudes towards science, technology, and online learning were nearly identical. There were no differences across sections in regard to course specifics, i.e. attitude toward the text, exams, etc.

Students in the online section were more likely to disagree with the idea that traditional classroom environments were necessary for learning to take place, and were slightly less apprehensive about taking an online course. Overall course quality was rated a full point lower than traditional sections, but still remained near the median of a seven-point scale (seven being a fantastic course).

There is one item of interest that Greg Waddoups discovered in some data he collected: when the class was asked about what they would like to see changed in the course, about 50% of those surveyed indicated that they wanted more web content and less in-class activities, while the remaining 50% indicated exactly the opposite.

### 4.2.1 In The Student's Own Words

The following are quotes taken directly from comment sections on the final survey. They are reproduced here in their original unedited format.

**What didn't you like about the course?**

> The computer didn't always work and i ended spending more time trying to figure out what was wrong. I spent a lot of time that could been spent other more constructive activities than emailing prof. and staff trying to fix problems.

> I am retaking this class and feel that the online course, currently enrolled in, is teaching anything new. There is very little interaction with the teacher or the other students. I know that human interactive learning is

the best possible learning - learned this through being a student as well as a teacher.

there is no teaching involved in the online class. I have ended up attending the normal classes because I was learning so little.

The strength and weakness, in my opinion, could very well be the same thing. Having the freedom to do it as I pleased, could be bad because there are many of us who have a slight problem with procrastination, and when other classes are more structured and have more deadlines, a lot of times it easier to ignore the internet class for awhile.

**What did you like about the course?**

time flexibility, extra material on web that explained book material in different ways than the book did. this helped clarify certain things. the computer animations and viewing video taped experiments was good. an excited teacher who genuinely is interested in our learning and understanding.

That we were still able to go to class and get feedback. The computer offered a new way of learning which was helpful.

I really liked the animations that were on the part online. It made it easier to understand the concepts. If you had any doubt you would see on the movie and it would make it clearer. And you can go at you own rate on the computer. If you understand a concept you can move through it quicker if not then you can spend more time on it.

I liked the online material. The examples and animations were good on the whole. I sometimes thought that the process of reading the text and then using the online material was a hassle. I wish that all of the course content were on the web.

## 4.3   Online Content and PER-based Paradigms

Section 1.1.1 mentioned several Physics Education Research (PER) based programs and paradigms for teaching physics. Student responses from the online section indicate that the Active Learning components (i.e. interactive animations and videos with follow-up questions) were favorably received (see Figures 3.14 and 3.16). Just-in-Time Teaching elements were used as the teacher of the online section reviewed

student work prior to developing content for the weekly in-class meeting time. Short answer questions that were in-line with web-based content helped students codify and synthesize what they had learned through writing (Physics by Inquiry). Again, there was a division among the online students as to how they rated the online content in these areas. Most students who used the online content on a regular basis gave high marks for the interactive nature of the course.[2]

Notably absent was any kind of group work or peer instruction with the exception of the Special Activities, which were sometimes done in groups. Peer Instruction techniques are not well suited for online courses that do not have a lecture-based element. In Physical Science 100 Online, Peer Instruction was possible but rarely used. From the first week of class the in-class hour was largely devoted to troubleshooting technical issues the students had and as a result, the pattern for peer association was never established. Additionally, the in-class hour became the time where the instructor could impose some structure and guidance for students who were struggling to meet deadlines and other course requirements. Peer Instruction can be implemented through a variety of means, and it remains to be determined if Peer Instruction via email or other online format is an effective method for enhancing student learning in this course.

## 4.4 Suggestions for Future Study

Further research needs to be done in regard to the Physical Science 100 Online offering at Brigham Young University. The course is still undergoing revision and changes. Most notable among them are the new Lesson Check-in questions and future plans for computer-based midterm exams. As the course changes, further studies will need

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[2]References to the PER paradigms mentioned here can be found in Section 1.1.1.

to investigate student performance, understanding, and student attitudes.

Survey tools were not tailored for this thesis, as they necessitated covering a wide range of University interests (see Section 1.3.3). Future studies should focus on student comprehension in light of common misconceptions. Eight concept quiz questions is not enough. Investigations should be made into published diagnostic tools such as the Force Concept Inventory (FCI) [20] and their applicability to PS100 Online.

In future studies, every effort should be made to eliminate voluntary participation on surveys, etc. while at the same time maintaining confidentiality. This is a sensitive issue, and universities must abide by federal guidelines and standards where human research subjects are used. Future investigators will need to contact their respective representatives from the Office of Research and Creative Activities (ORCA) for information regarding legal issues surrounding studies such as these.

## 4.5  Suggestions for Teachers of Online Courses

Though not a formal part of this study, information regarding the implementation and delivery of an online course was gathered. This section is for the curious, or those who find themselves in the position of having to teach an online course. Experiences are drawn from PS100 Online, but have application across different subject matter areas as they deal more with technologies and methods than pedagogy.

Online courses can be exhilarating. For the student who is truly engaged, online content is a boon. I had the opportunity to overhear several in-class conversations between students and professors about the activities they had engaged in online. For this small minority, the online content had them thinking, asking, and pondering on the principles of physical science. Large lecture sections never seem to engender this

excitement into all but one or two students. This phenomenon seemed to be more prevalent in the online section.

Unfortunately, there is a much greater opportunity for frustration in an online learning environment. Technical issues take a large toll on learning. Courses must be designed to weather the worst if they are to be offered on the web, and careful testing must be done prior to publicly offering such a course. PS100 Online is learning the hard way, but it is the first ever fully online offering for the University. Other "online" courses have been in fact "offline" in a strict sense of the word, with all but communication content (i.e. announcements, email, and quizzes) being delivered on CD-ROM.

Educators need to have a good technical support system in place, otherwise a majority of the teacher's time is relegated to fixing technical problems. There is a tendency in the online paradigm for educators to become programmers, technicians, and graphical designers. This must not occur. The role of the instructor must be preserved in online learning environments, and this can be maintained with dedicated technical support personnel.

The time commitment for the instructor is more than that of a traditional course. This was evidenced by my own experience in teaching PS100 and the experiences of others. Rather than a fixed set of office hours and lecture periods, students have access to the teacher on an almost constant basis via email, and the instructor can quickly become overwhelmed if emails are not answered promptly. A majority of time is spent in online communications, and repetition is more frequent that in a traditional course. This can be alleviated though the use of messageboards, but the fact remains that email communication is preferred by students overall.

Finally, the lack of feedback on how your students are doing and what they are

understanding can be frustrating. I call this the "eye-contact effect". In a traditional environment where students are present, an instructor can gauge student understanding based on experience and student body language. While not always correct, these perceptions allow the instructor to make dynamic adjustments to the course. This phenomenon is utterly lacking in an online offering, and is a hard fact to deal with. There is a sense of not having control that comes with online territory, be it the inability to structure the course pages to your specific style and philosophy to simply not knowing how well your students are understanding the material.

I believe that there is a place for online courses in lower division university classes. I feel that it is important for educators to remain educators. The Internet is a communication medium, not wholly incomparable to a piece of chalk or an overhead projector. I think there are several years ahead of us in which online learning environments will continue to grow and develop, and not without bumps along the way.

## 4.6 Summary

Section 1.3.1 provided a set of goals that were to be achieved by this thesis projects. To summarize, each of these goals is presented and commented on.

**Evaluate the impact of an online offering on common student misconceptions regarding basic physics principles**

The online offering of Physical Science 100 had the same impact on student misconceptions as that of the traditional course. In both cases, scores improved on concept based questions (see Section 3.6).

**Define criteria and methods important for longer, more rigorous studies in physics based courses**

These criteria were touched on in Section 4.4. It should be noted that future studies should be limited in scope, and focus on further inquiry into student conceptions of physical science principles.

**Evaluate web-based physical science instruction on the basis of accommodating various cognitive and intentional learning styles**

The ILOQ (see Appendix C) did not provide any insight into this question. There was a wide range of ILOQ scores in all the sections studied, and though there were some significant correlations with certain variables in the study (see Section 3.4) they were not strong. Thus far, the course seems not to cater to any particular learning style, though those who are technologically adept are at an advantage as far as ease of use is concerned.

**Compare student performance and attitudes in the web-based physical science sections to those in traditional classroom settings in light of differing learning styles**

Student attitudes and performance were not different across the sections studied, and no significant correlations were found between performance and learning styles. This finding supports the "No Significant Difference" phenomenon and provides a data point for the subject area of physical science. It should be noted that students did not use the web pages as intended by the course architects and authors (see Section 3.7), which may have contributed to the lack of difference between sections.

# Appendix A

# Survey Tools

The following pages contain copies of the three survey tools used during the Fall 2000 study. In order, they are the Pre-survey, ILOQ, and Post-survey. They are reproduced here exactly as the students saw them.

# Appendix B

# Descriptive Statistics

The following pages contain frequency plots for all questions asked on the Pre and Post-surveys. The Count variable measures the number of times a particular answer was given for that question. Captions indicate the question number and text.
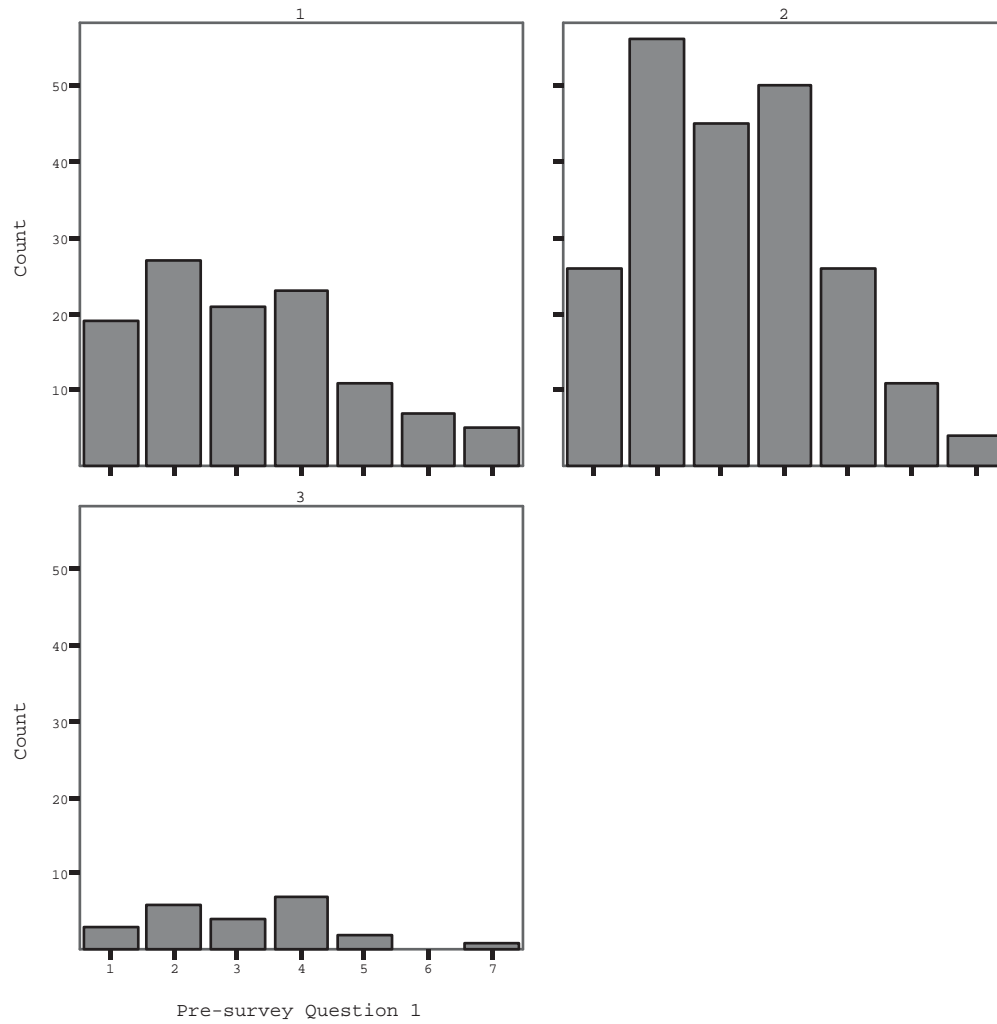
Figure B.1: Results from Pre-survey question 1, "I lose interest when a scientific topic appears on television news." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
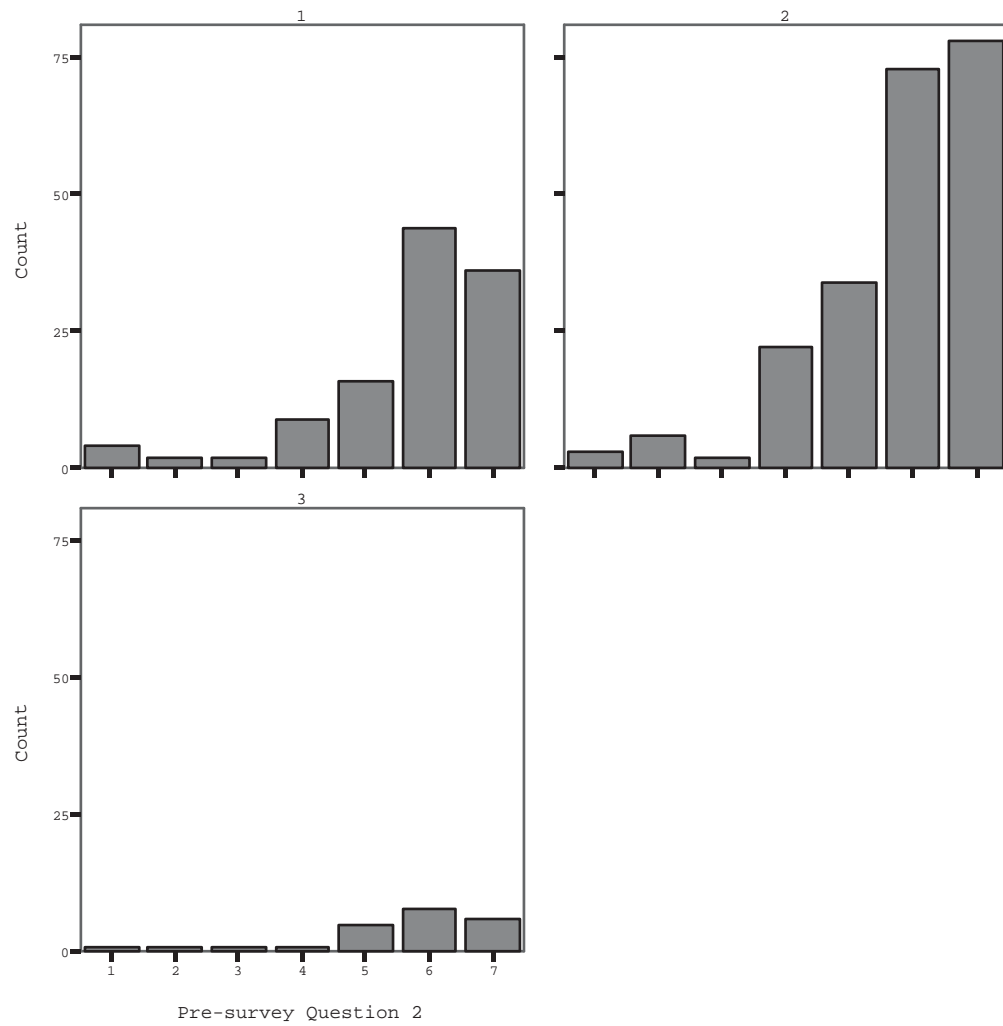
Figure B.2: Results from Pre-survey question 2, "Science generally contributes to human progress." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
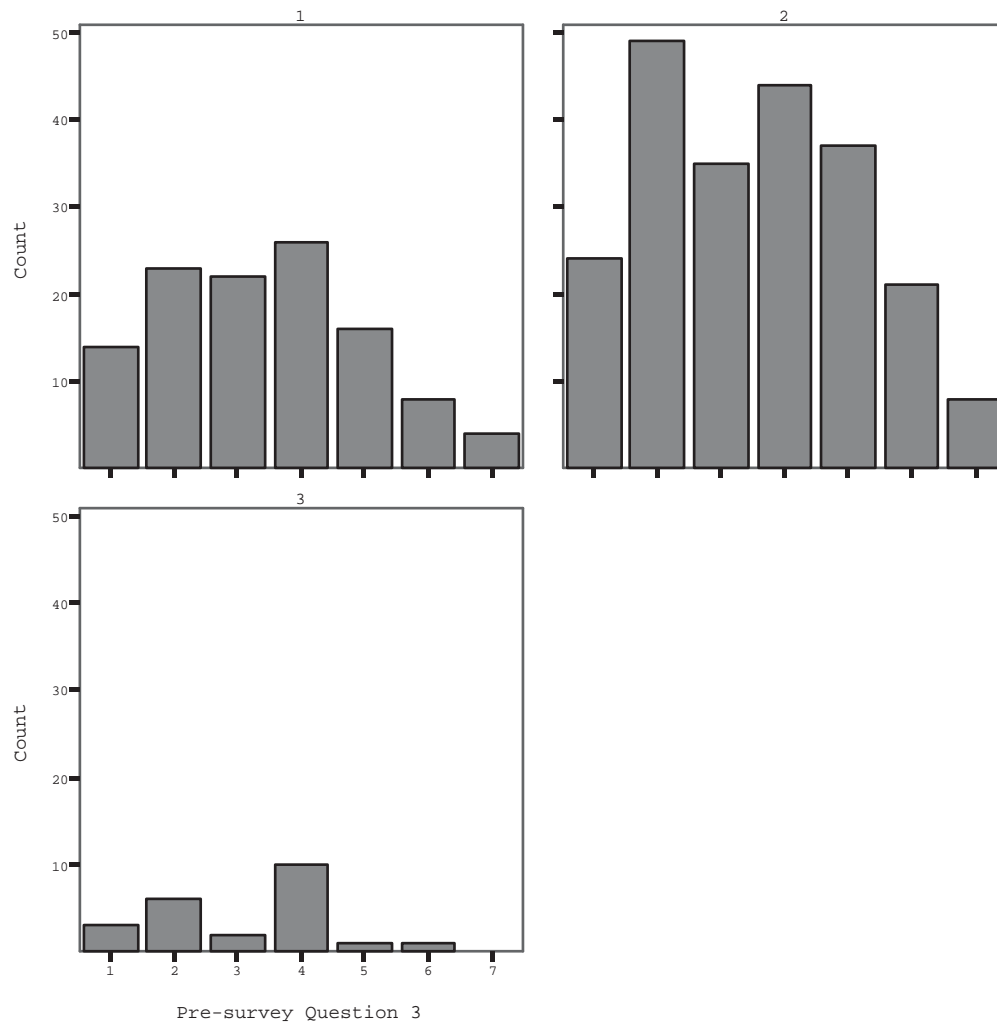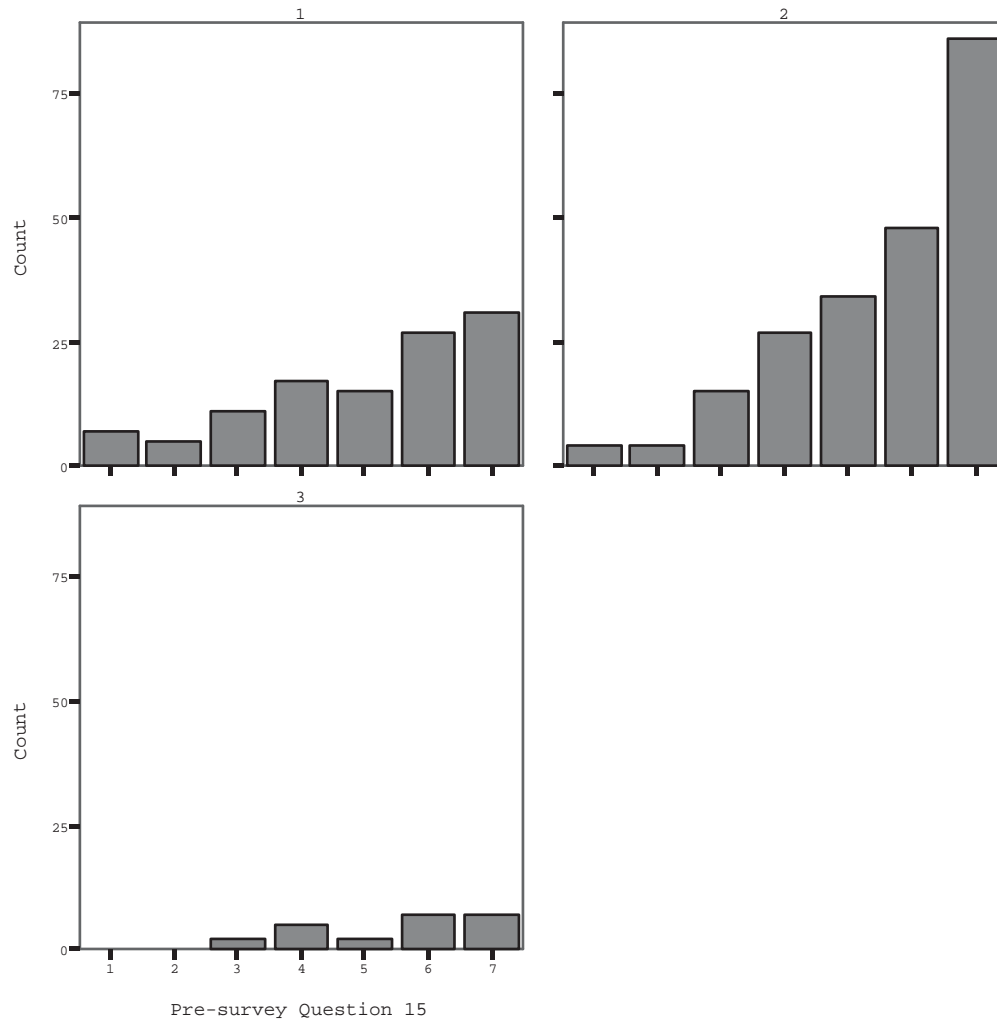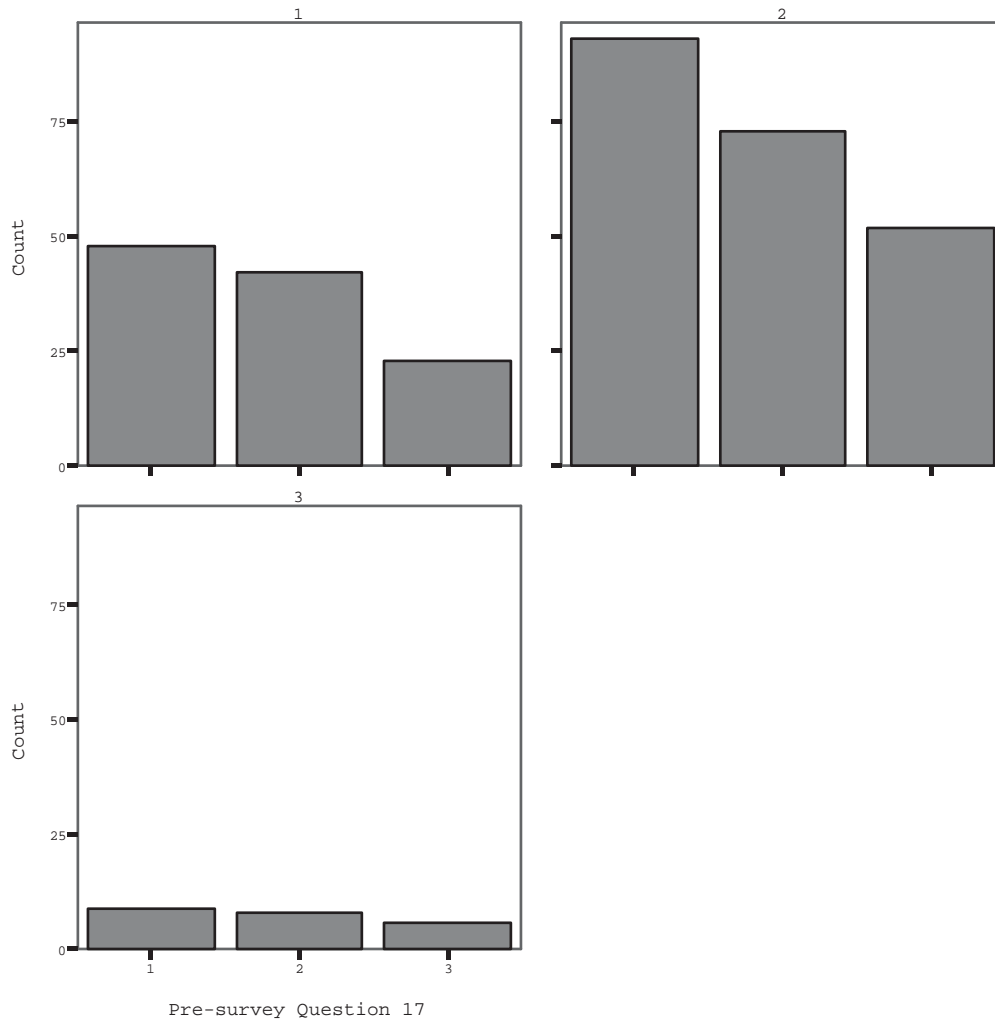
Figure B.3: Results from Pre-survey question 3, "I become bored when scientific issues are raised in casual conversation." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
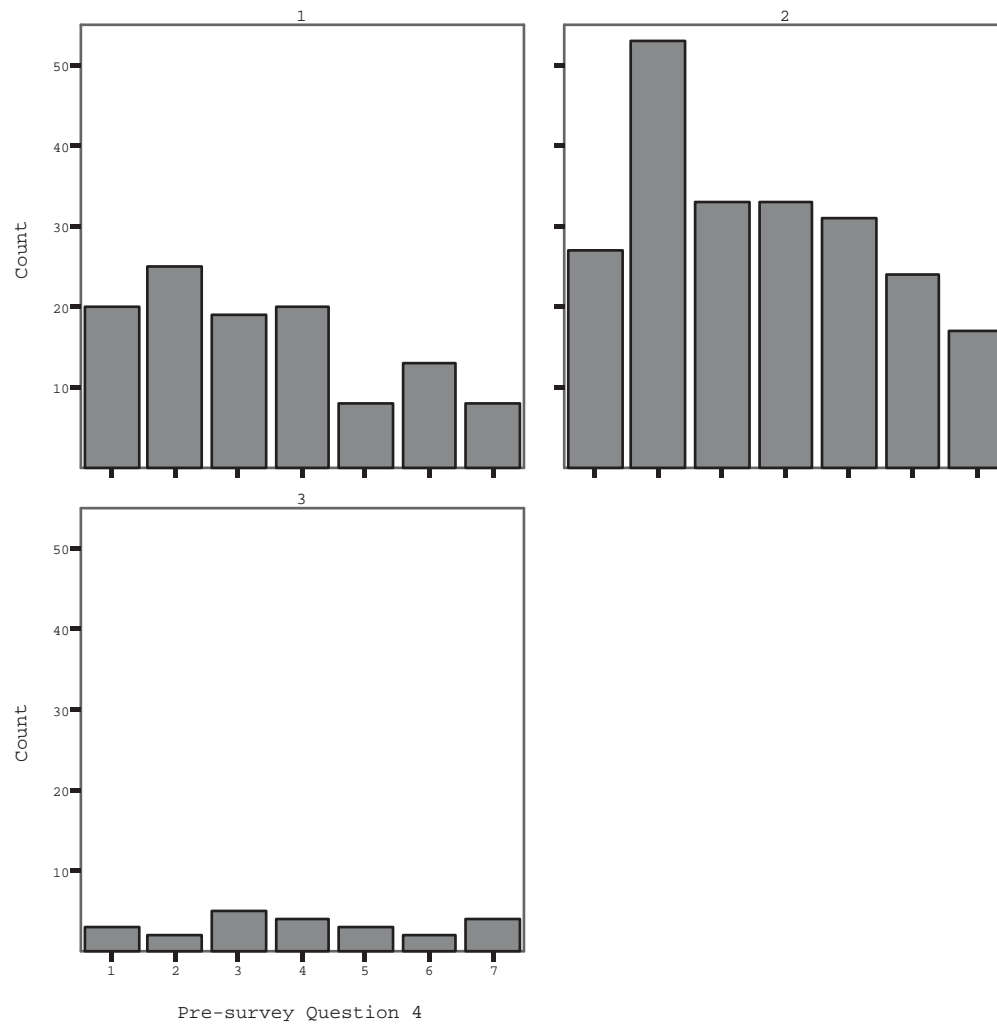
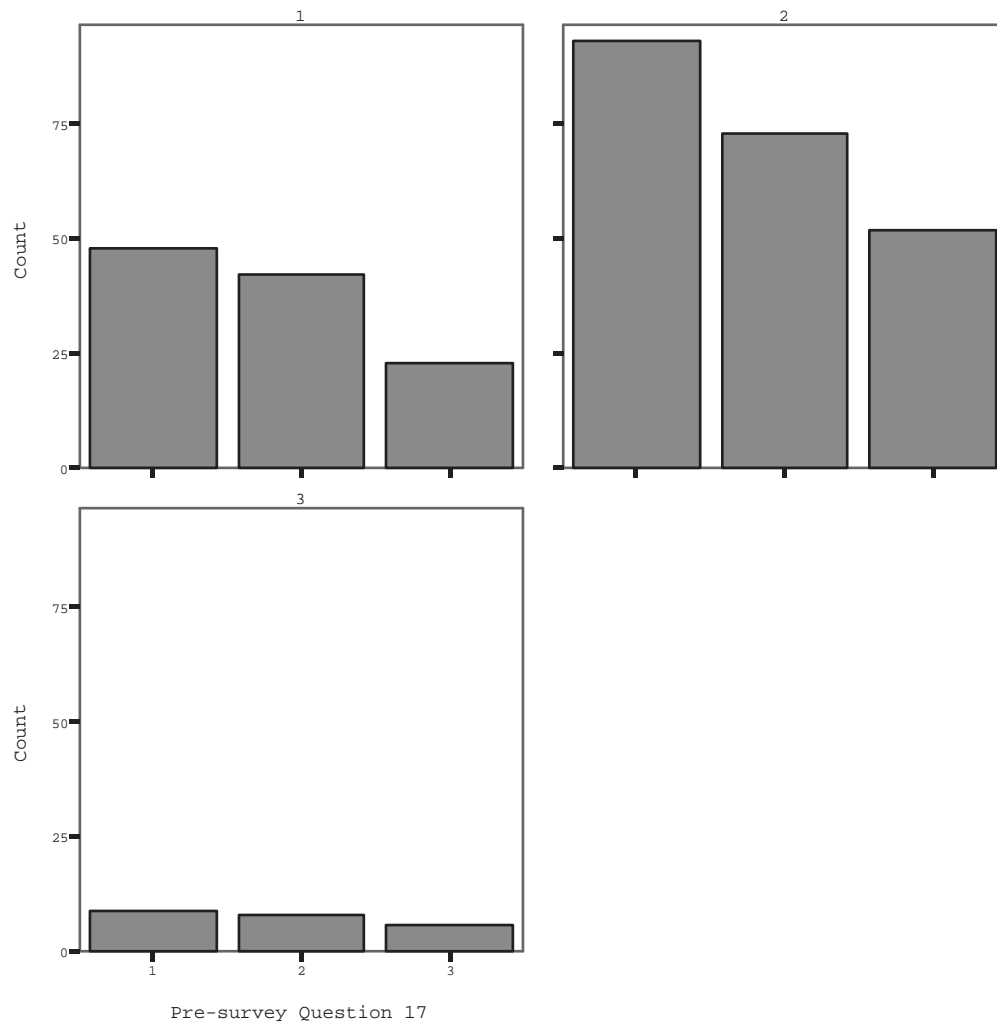Figure B.4: Results from Pre-survey question 4, "I am interested in choosing a career that involves scientific knowledge." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).

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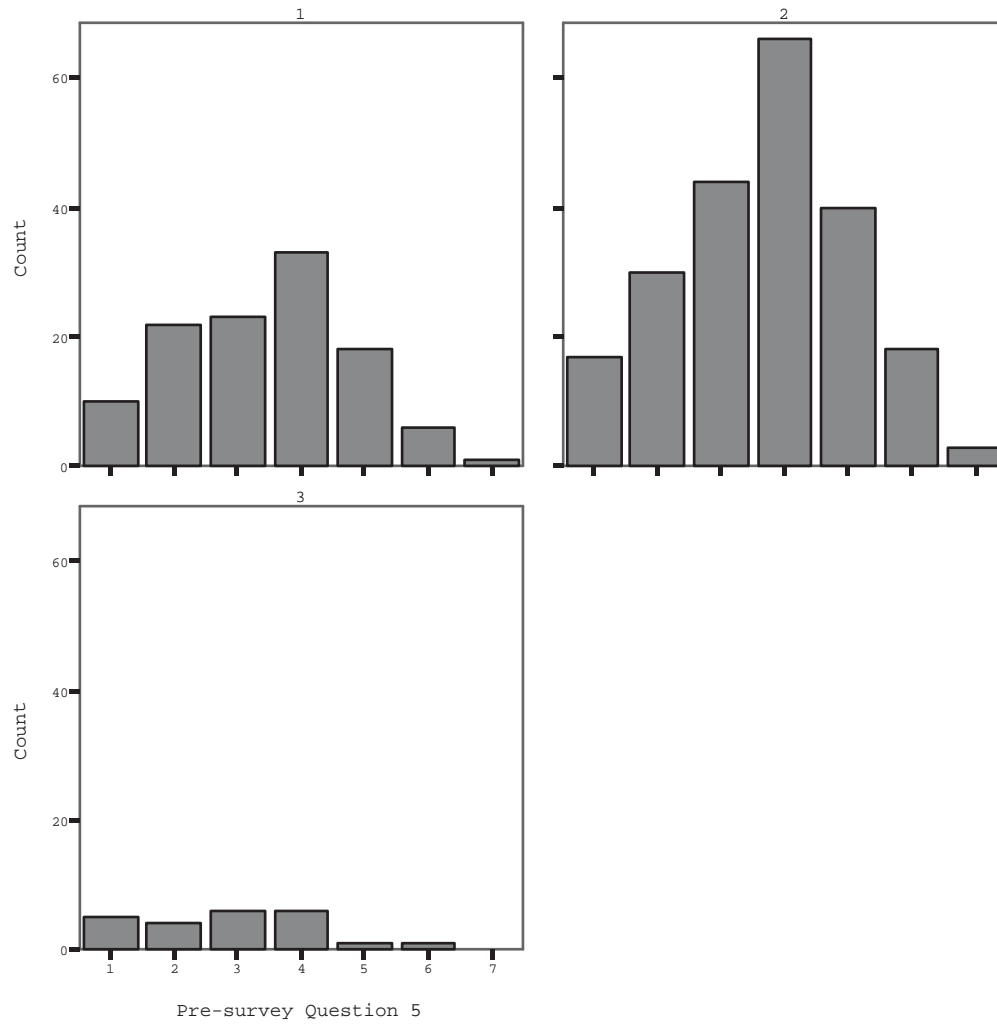
Figure B.5: Results from Pre-survey question 5, "Science is cold and impersonal." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
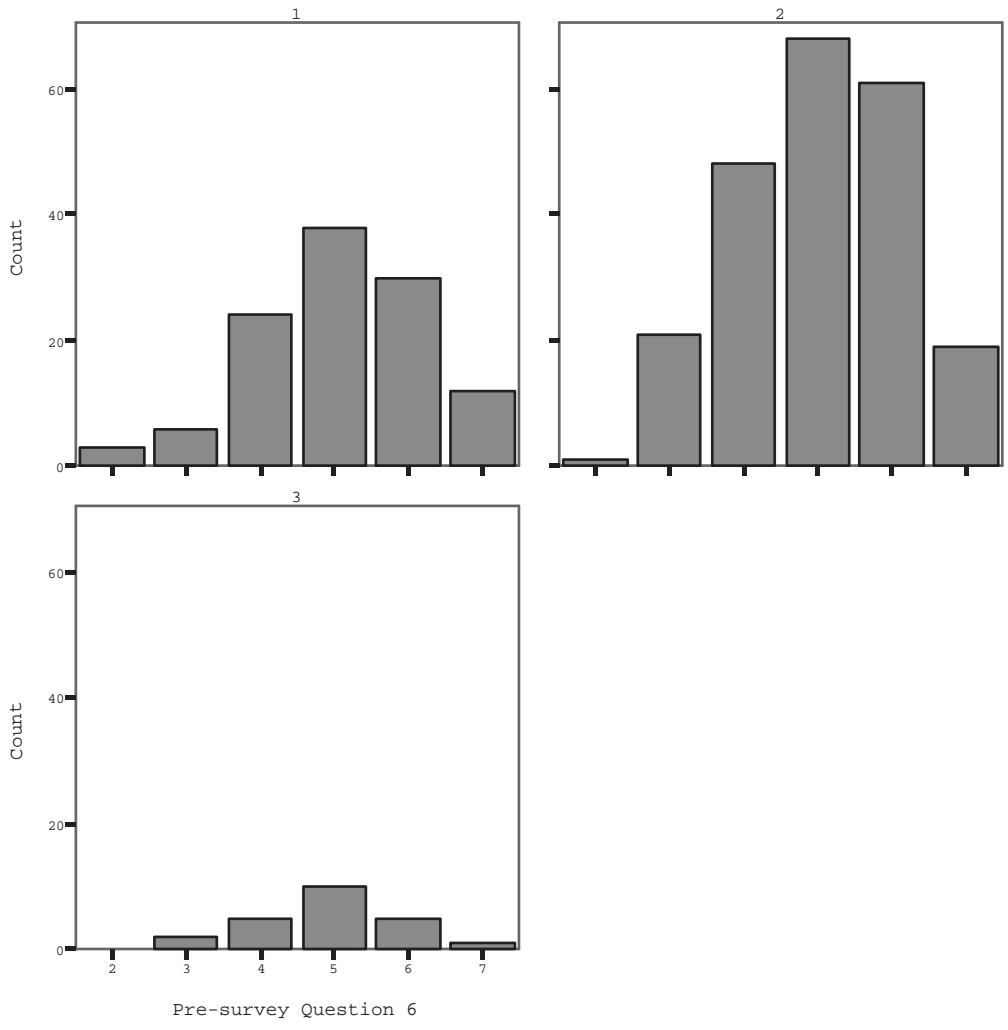
Figure B.6: Results from Pre-survey question 6, "Rate your competence using the following computer applications: Using a Personal Computer". 7="Advanced", 1="No Experience". Section numbers are indicated at the top of each graph (Section 3 is online).
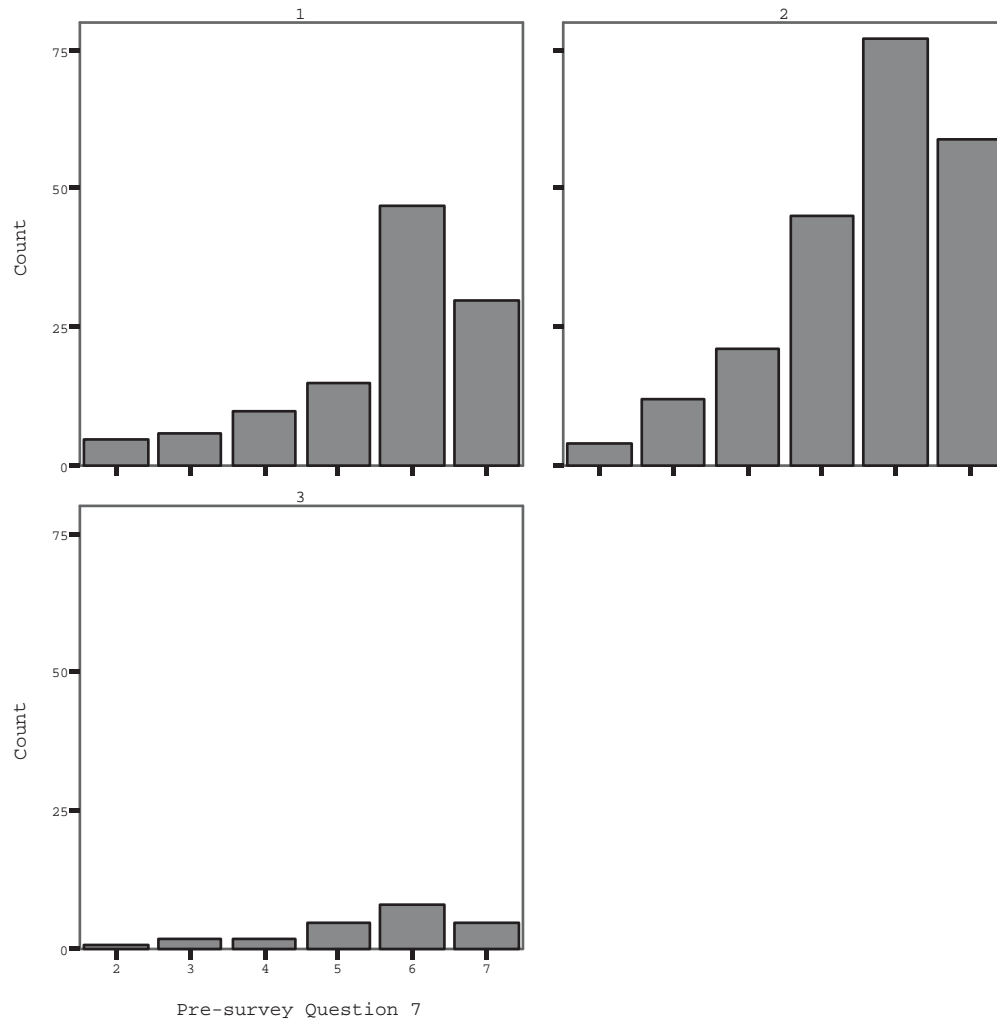
Figure B.7: Results from Pre-survey question 7, "Rate your competence using the following computer application: Email Communications". 7="Advanced", 1="No Experience". Section numbers are indicated at the top of each graph (Section 3 is online).
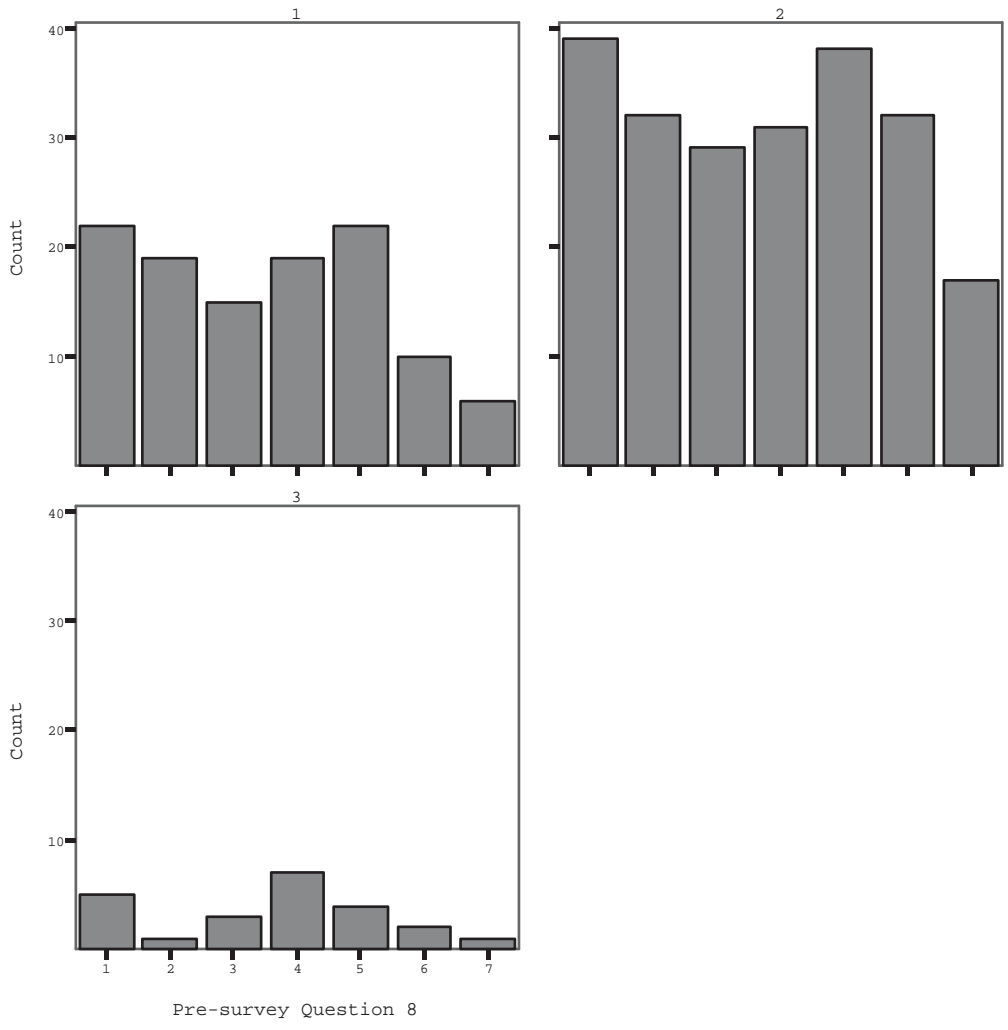
Figure B.8: Results from Pre-survey question 8, "Rate your competence using the following computer application: Group Discussion (Electronic Bulletin-Board/Chat)". 7="Advanced", 1="No Experience". Section numbers are indicated at the top of each graph (Section 3 is online).
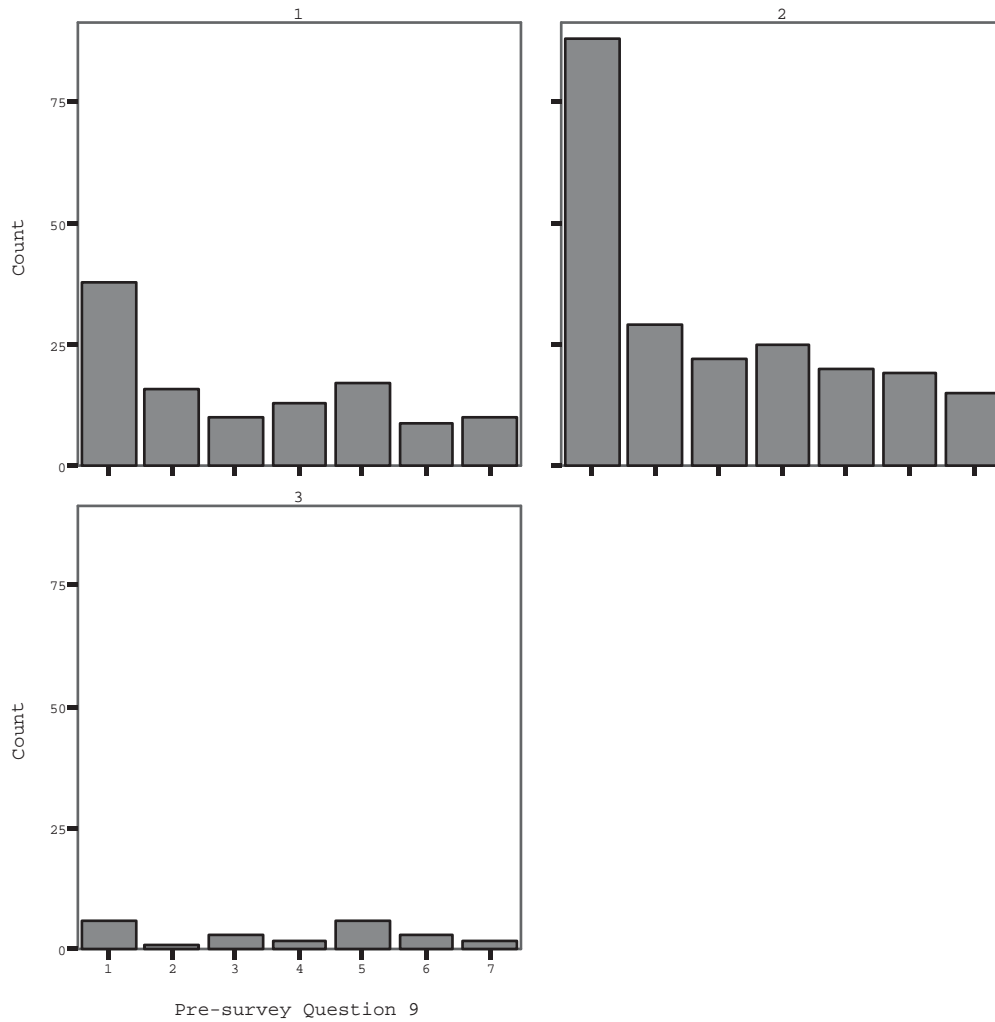
Figure B.9: Results from Pre-survey question 9, "Rate your competence using the following computer application: Accessing video from WWW using Plug-ins such as Quicktime". 7="Advanced", 1="No Experience". Section numbers are indicated at the top of each graph (Section 3 is online).
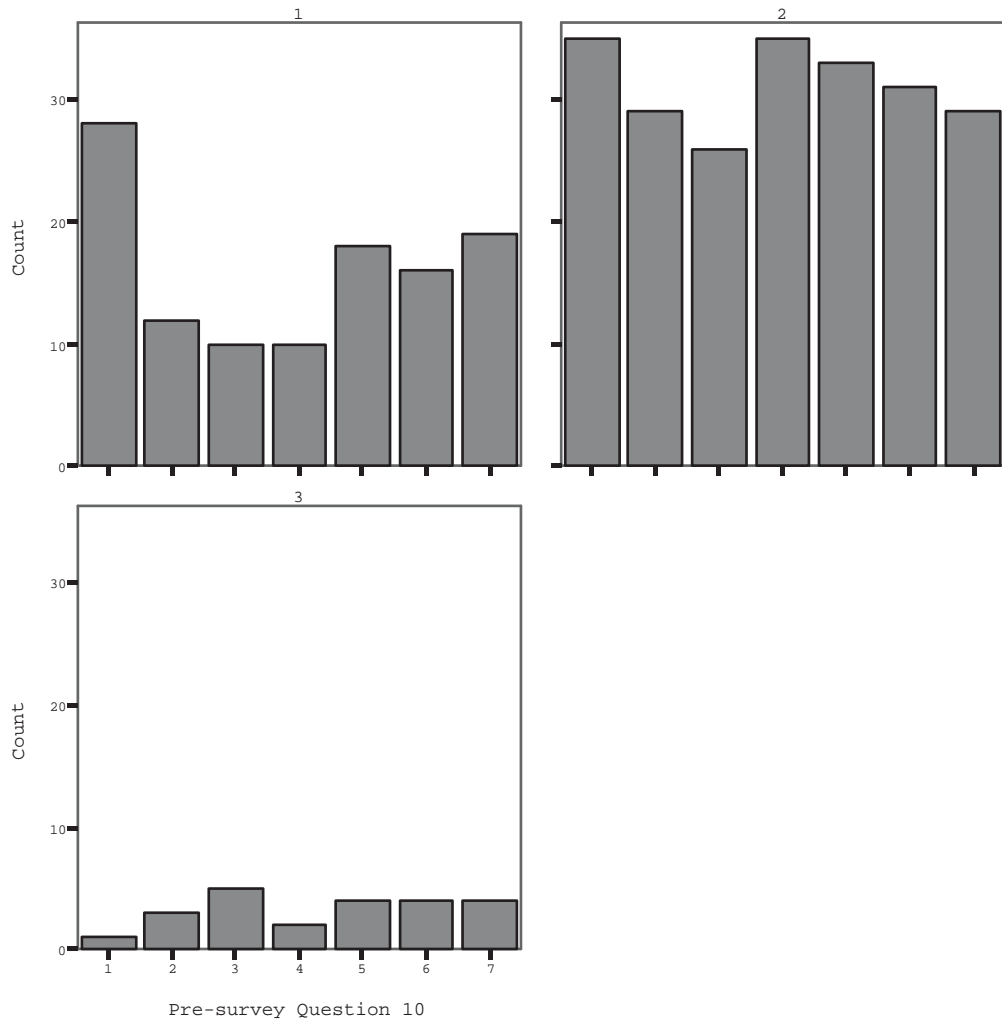
Figure B.10: Results from Pre-survey question 10, "Rate your competence using the following computer application: Downloading programs from the Internet". 7="Advanced", 1="No Experience". Section numbers are indicated at the top of each graph (Section 3 is online).
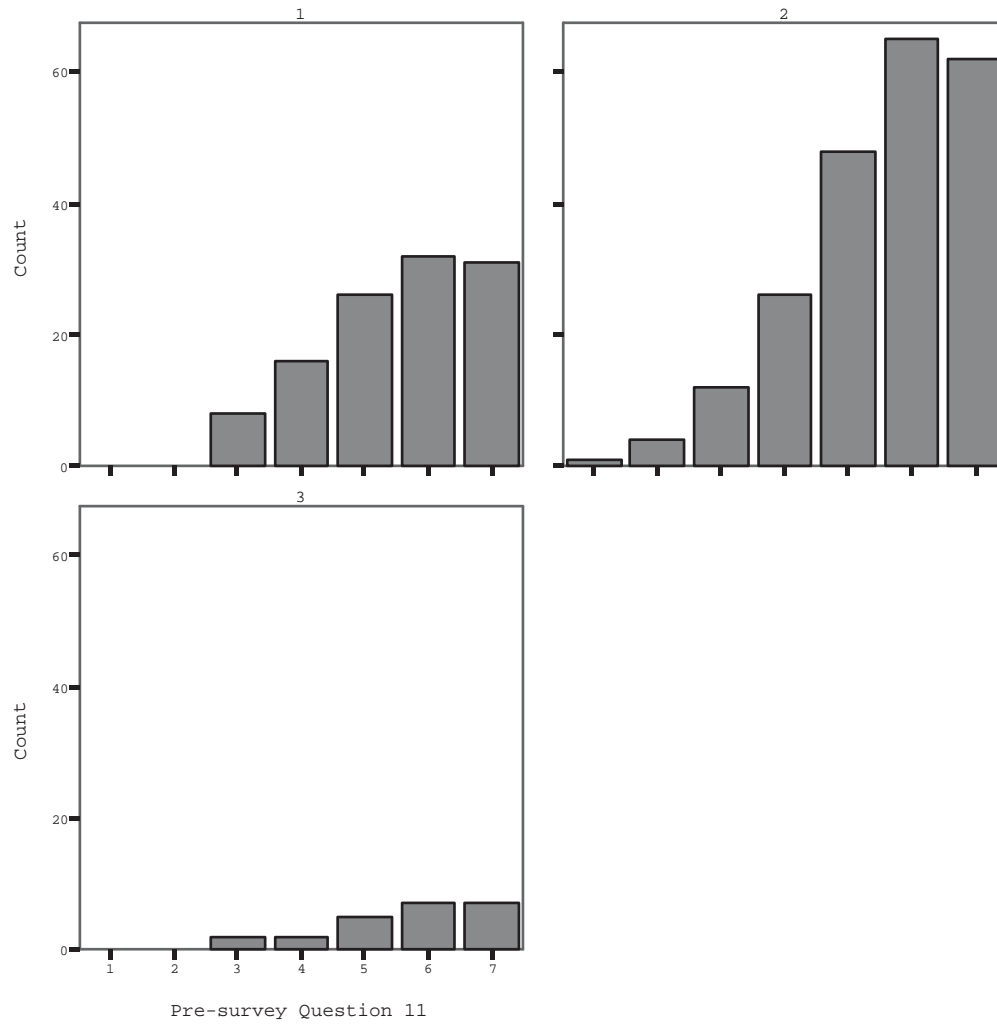
Figure B.11: Results from Pre-survey question 11, "I enjoy using a computer in general." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
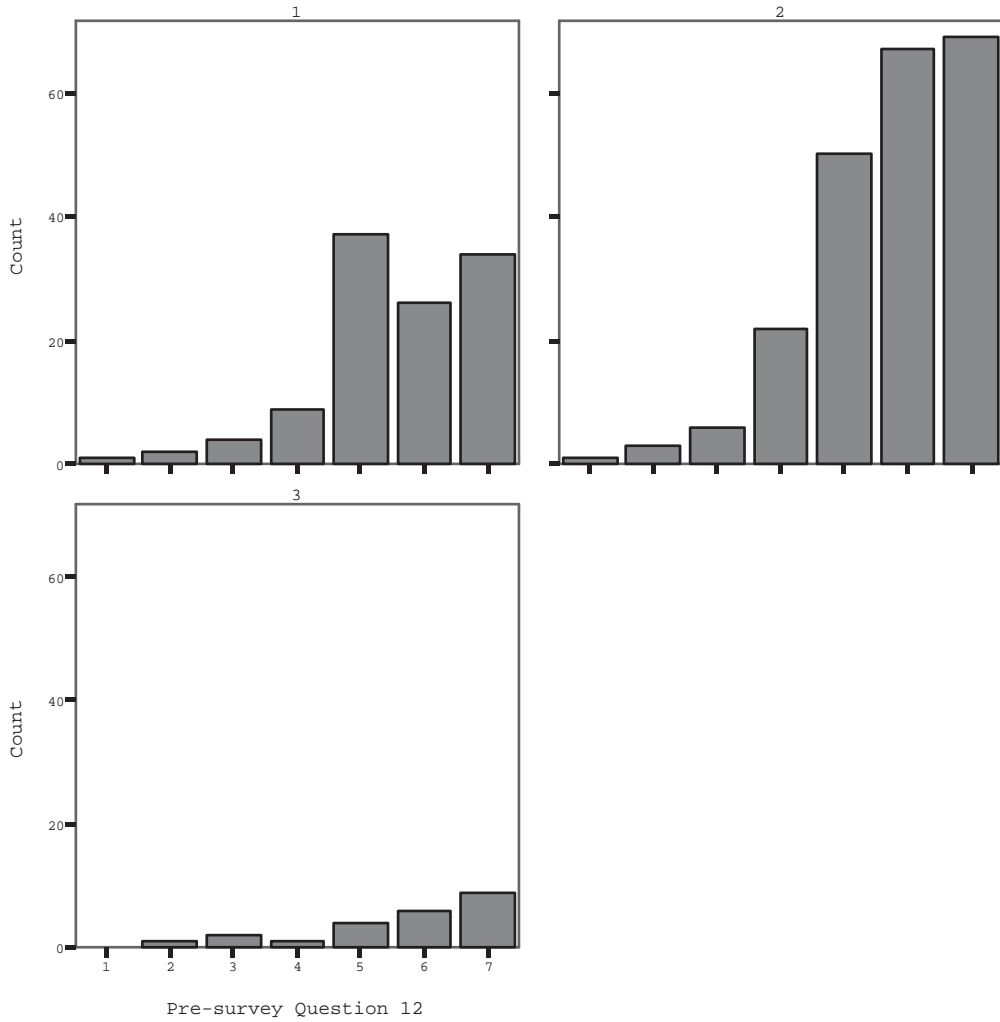
Figure B.12: Results from Pre-survey question 12, "I enjoy using the Internet." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
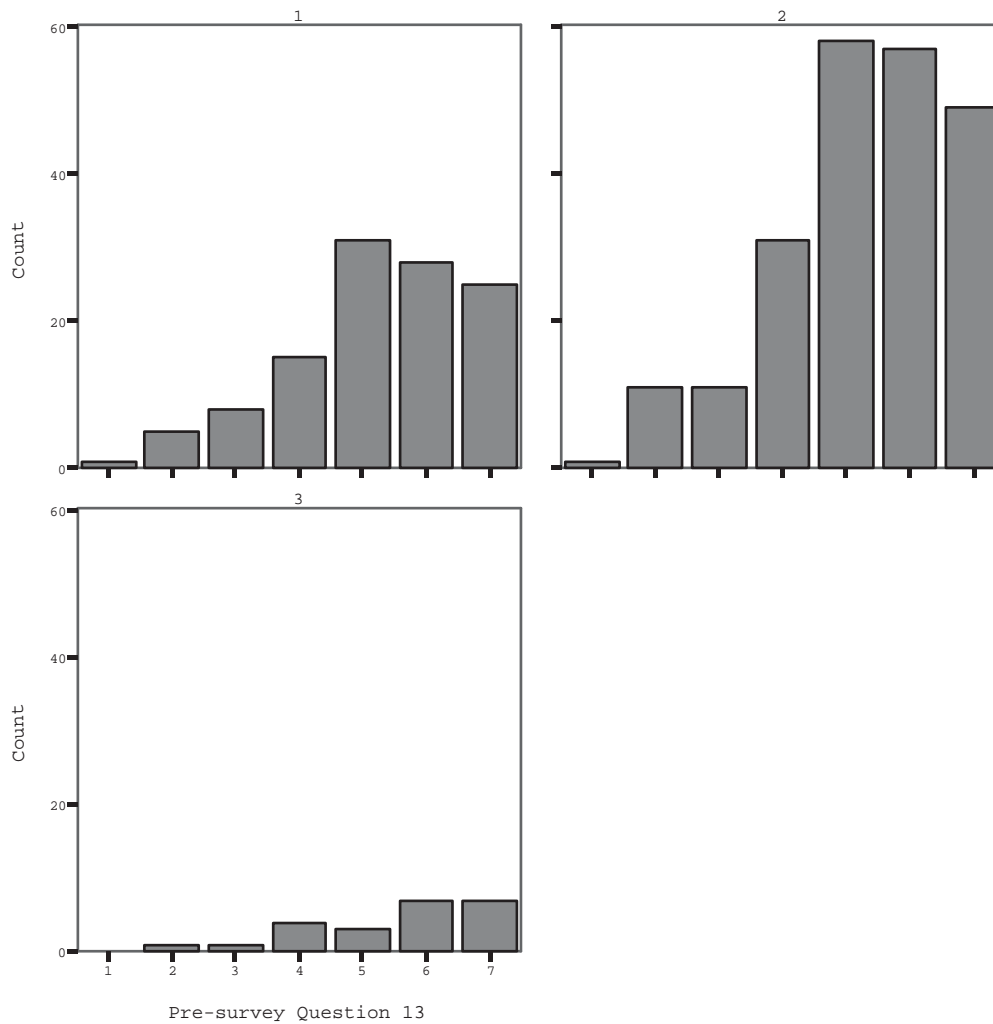
Figure B.13: Results from Pre-survey question 13, "I am motivated to use new technologies." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).
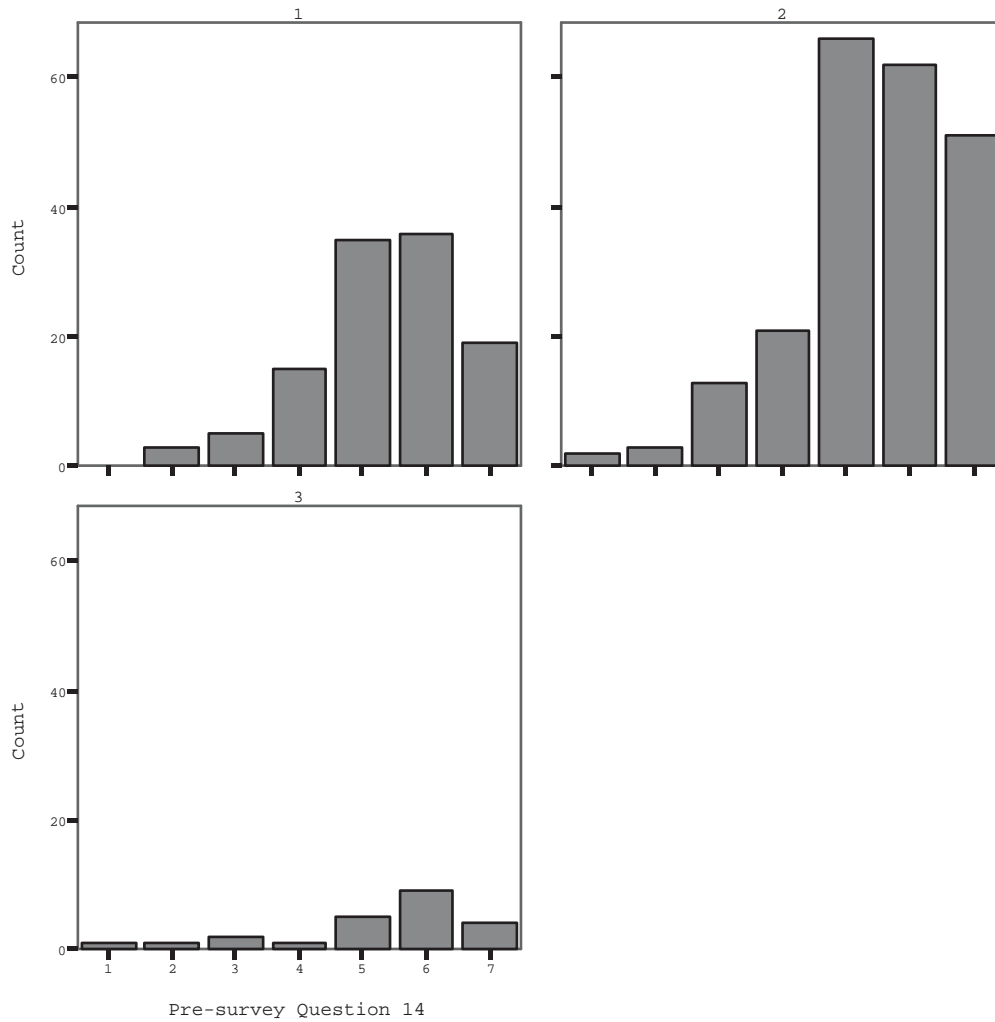
Figure B.14: Results from Pre-survey question 14, "When I am asked to use new technologies, I will try them even if I feel a bit apprehensive." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.15: Results from Pre-survey question 15, "It is not necessary to be in a traditional classroom environment to learn." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.16: Results from Pre-survey question 16, "I believe computer-based training via the web is not as effective as traditional training." 7="Strongly Agree", 1="Strongly Disagree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.17: Results from Pre-survey question 17, "I learn best: 1) On my own, 2) with a partner, 3) in a study group." Section numbers are indicated at the top of each graph (Section 3 is online).
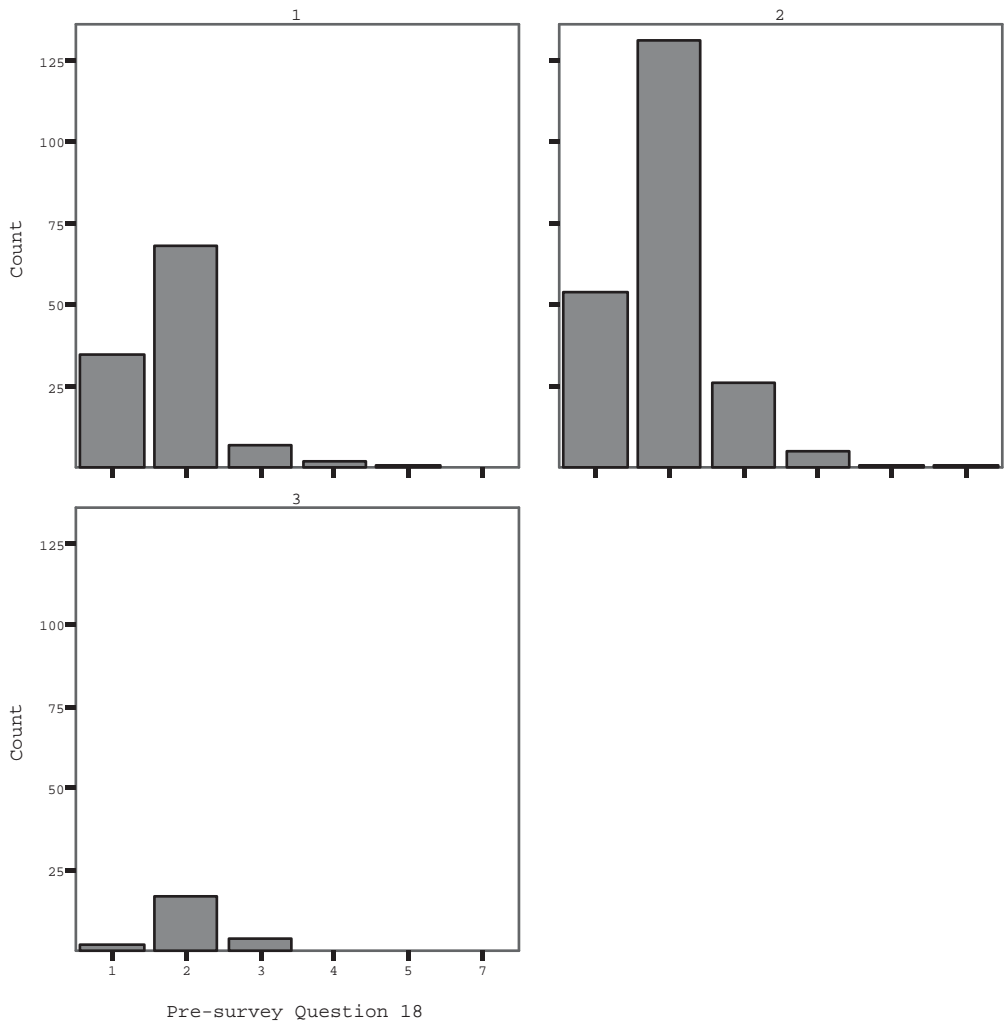
Figure B.18: Results from Pre-survey question 18, "On average in your regular (not online) classes, how many times per week do you interact (e.g., ask questions in class, talk after class, email or phone, etc.) with the instructor? 1) Never, 2) 1-3, 3) 4-6, 4) 7-10, 5) more than 10." Section numbers are indicated at the top of each graph (Section 3 is online).
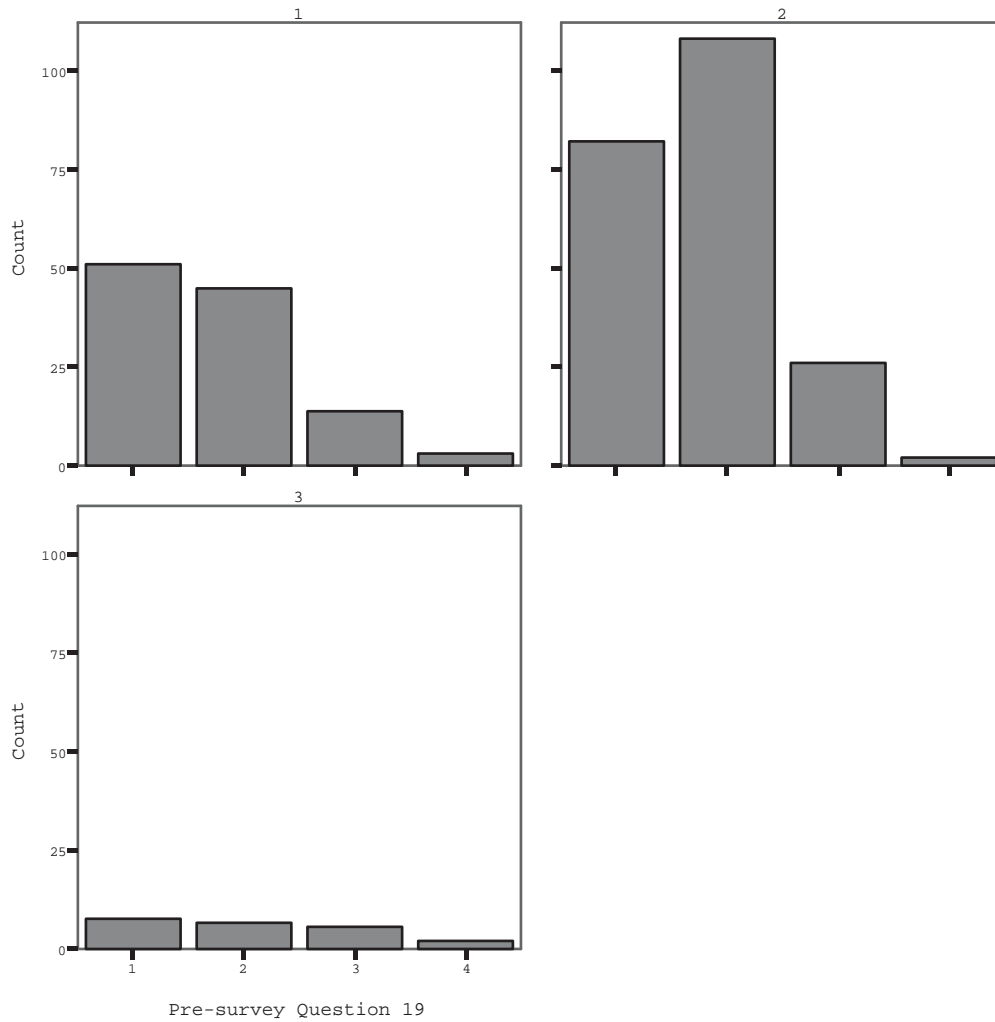
Figure B.19: Results from Pre-survey question 19, "My feelings toward online courses could be characterized as: 1) Apprehensive, 2) Indifferent, 3) Confident, 4) Very Confident". Section numbers are indicated at the top of each graph (Section 3 is online).
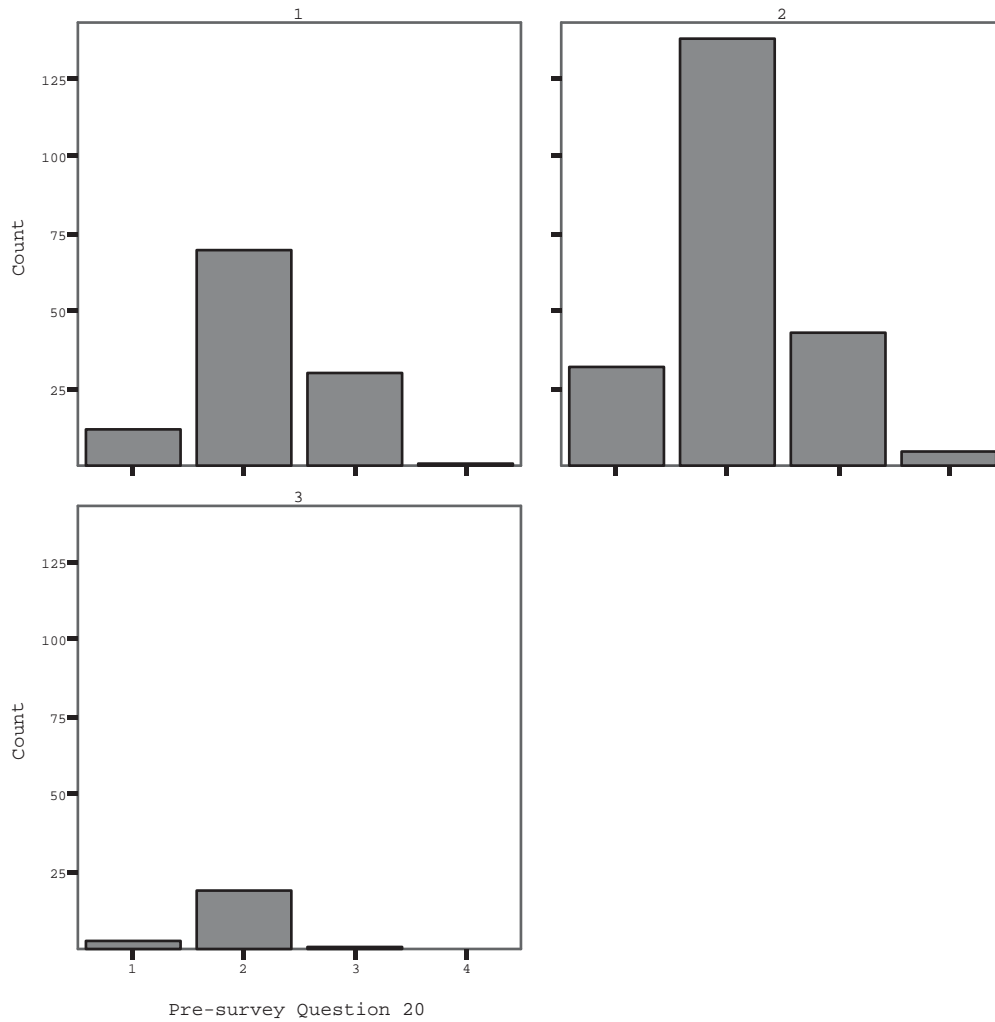
Figure B.20: Results from Pre-survey question 20, "I anticipate the time requirement for this course (per week) to be: 1) less than three hours, 2) more than three but less than six hours, 3) more than six but less than nine hours, 4) more than nine hours". Section numbers are indicated at the top of each graph (Section 3 is online).
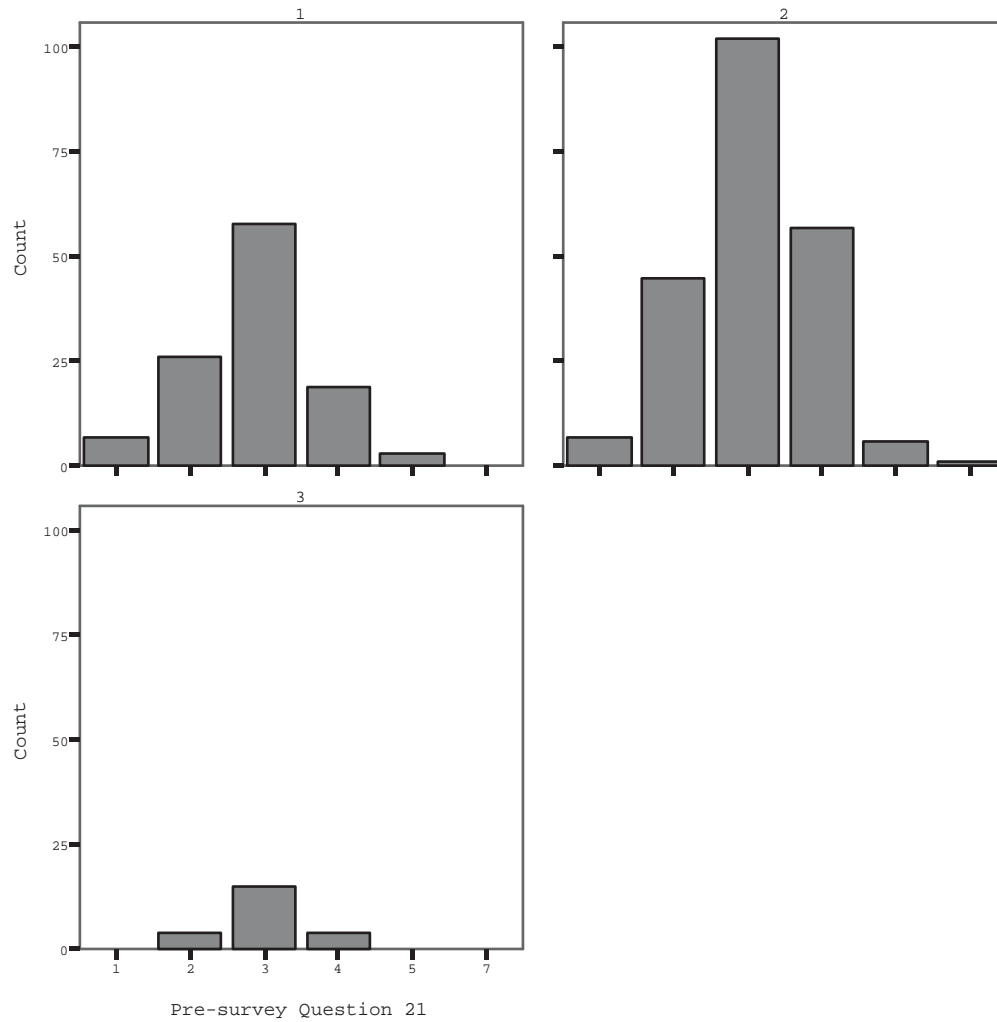
Figure B.21: Results from Pre-survey question 21, "Compared to other courses, I expect this courses difficulty to be: 1) much easier, 2) easier, 3) about the same, 4) harder, 5) much harder". Section numbers are indicated at the top of each graph (Section 3 is online).
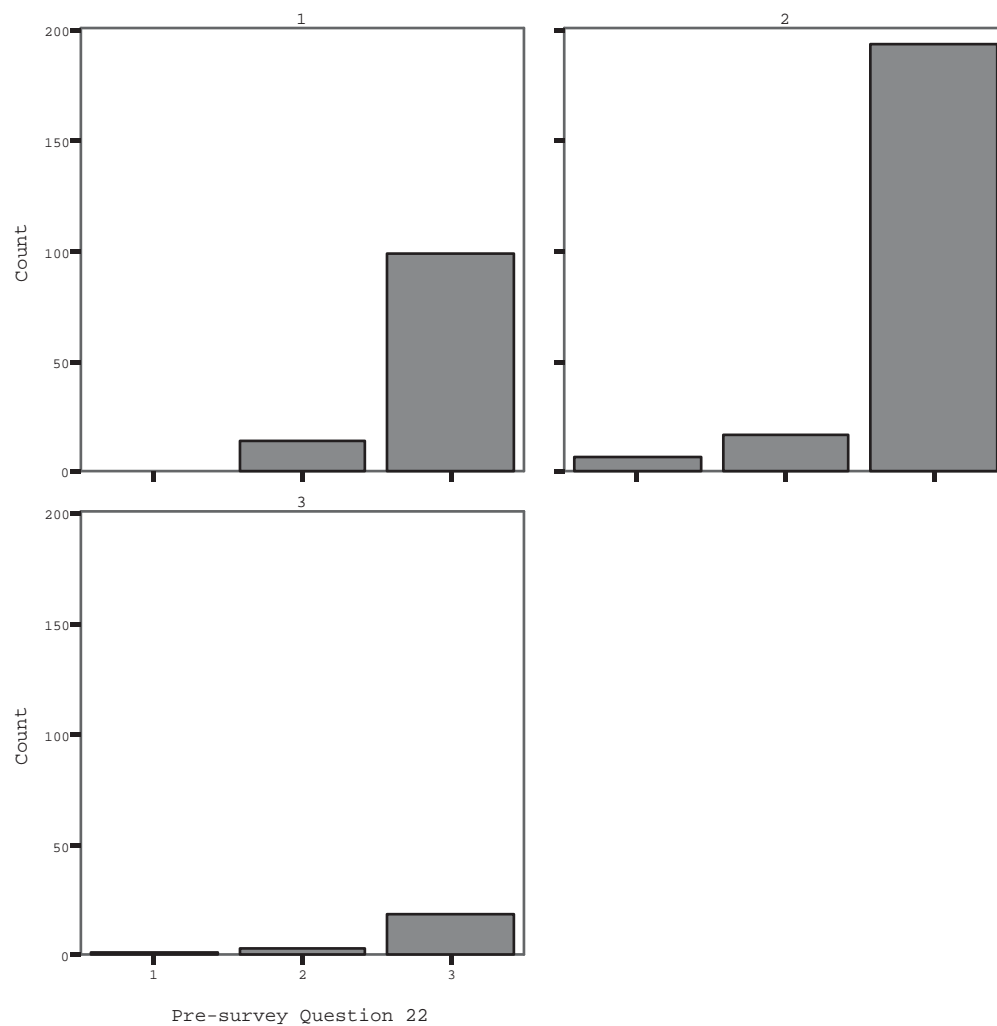
Figure B.22: Results from Pre-survey question 22, "A cannonball is launched from a cannon off of a high cliff. Which of the following statements is true? 1) The cannonball experiences no force after it leaves the cannon, 2) The cannonball's velocity doesn't change after it leaves the cannon, 3) The cannonball's acceleration and velocity are different". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).
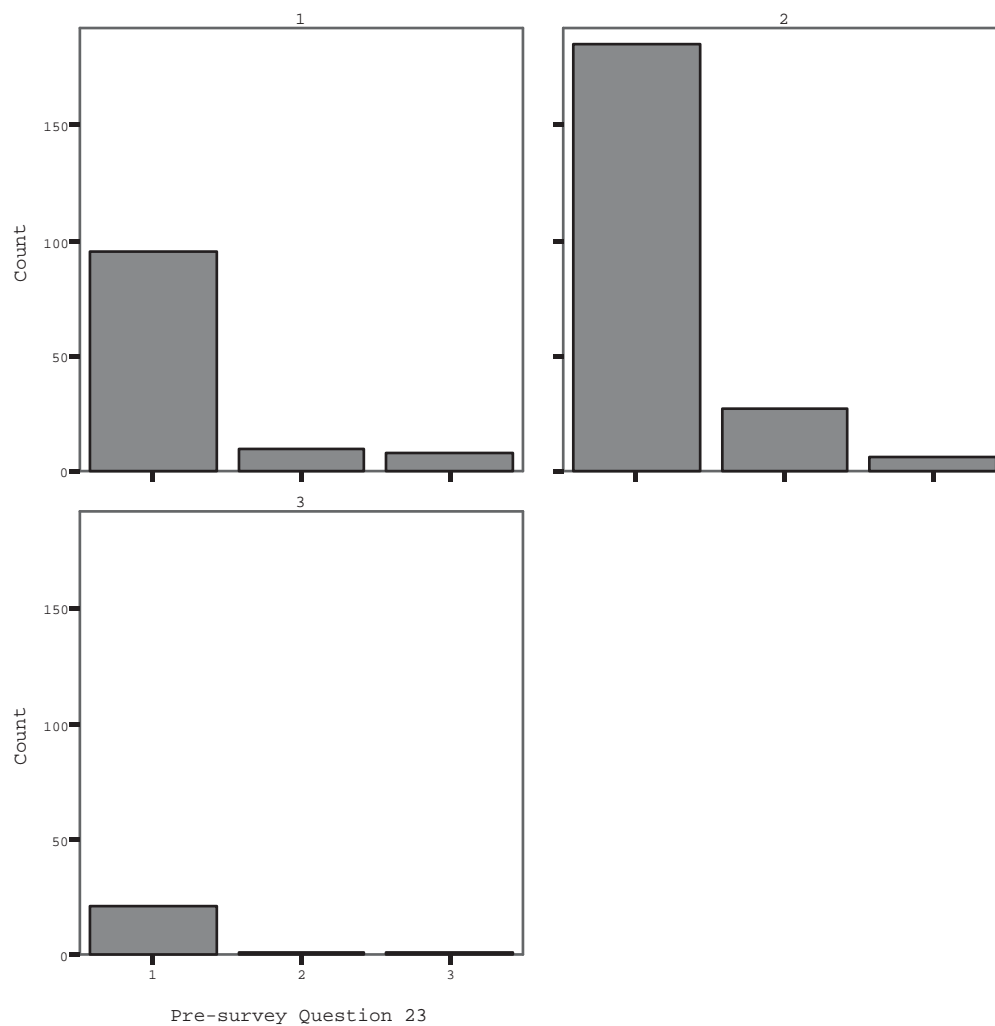
Figure B.23: Results from Pre-survey question 23, "A ball is thrown straight up in the air. At the top of its flight (highest point before falling back down), which of the following statements is true? 1) The acceleration of the ball is zero, 2) The acceleration of the ball is towards the earth, 3) The acceleration of the ball is away from the earth". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).
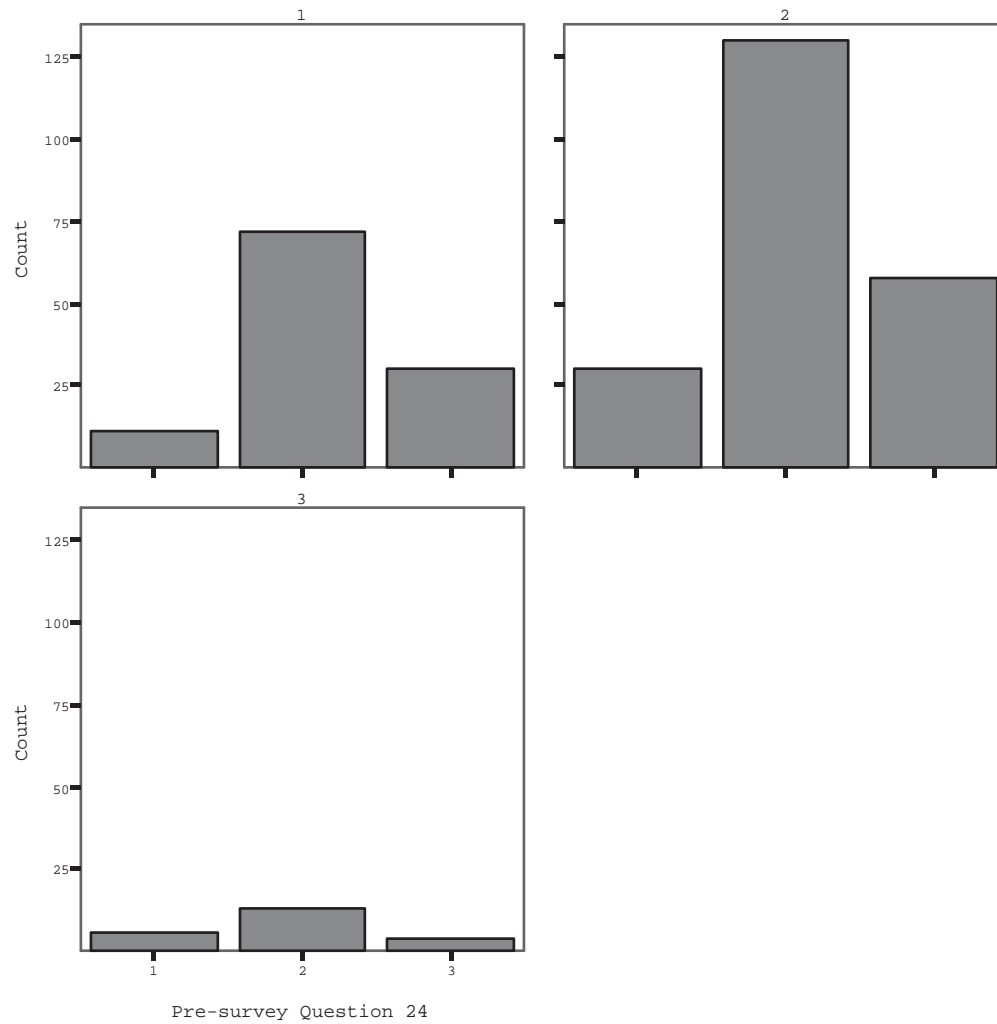
Figure B.24: Results from Pre-survey question 24, "Which of the following statements about the nature of light is true? 1) Light is either a particle or a wave, but not both, 2) Light is both a wave and a particle, 3) Light can be a particle at one point in time and wave at another point in time". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).
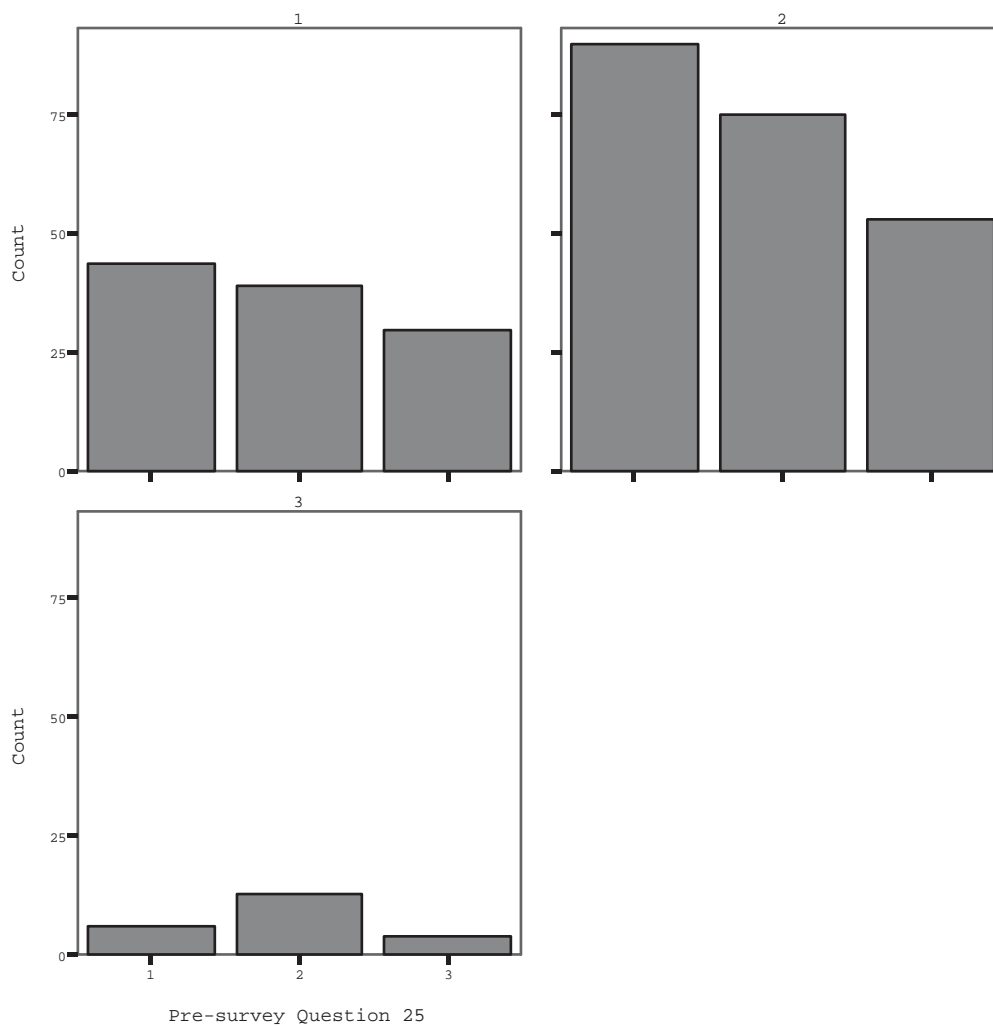
Figure B.25: Results from Pre-survey question 25, "A cart on a frictionless track slides from a high point to a low one. What can be said about the total amount of energy it has at the low spot? 1) It is the same as the total energy it had at the top, 2) It is greater than the total energy it had at the top, 3) It is less than the total energy it had at the top". The correct answer is #1. Section numbers are indicated at the top of each graph (Section 3 is online).
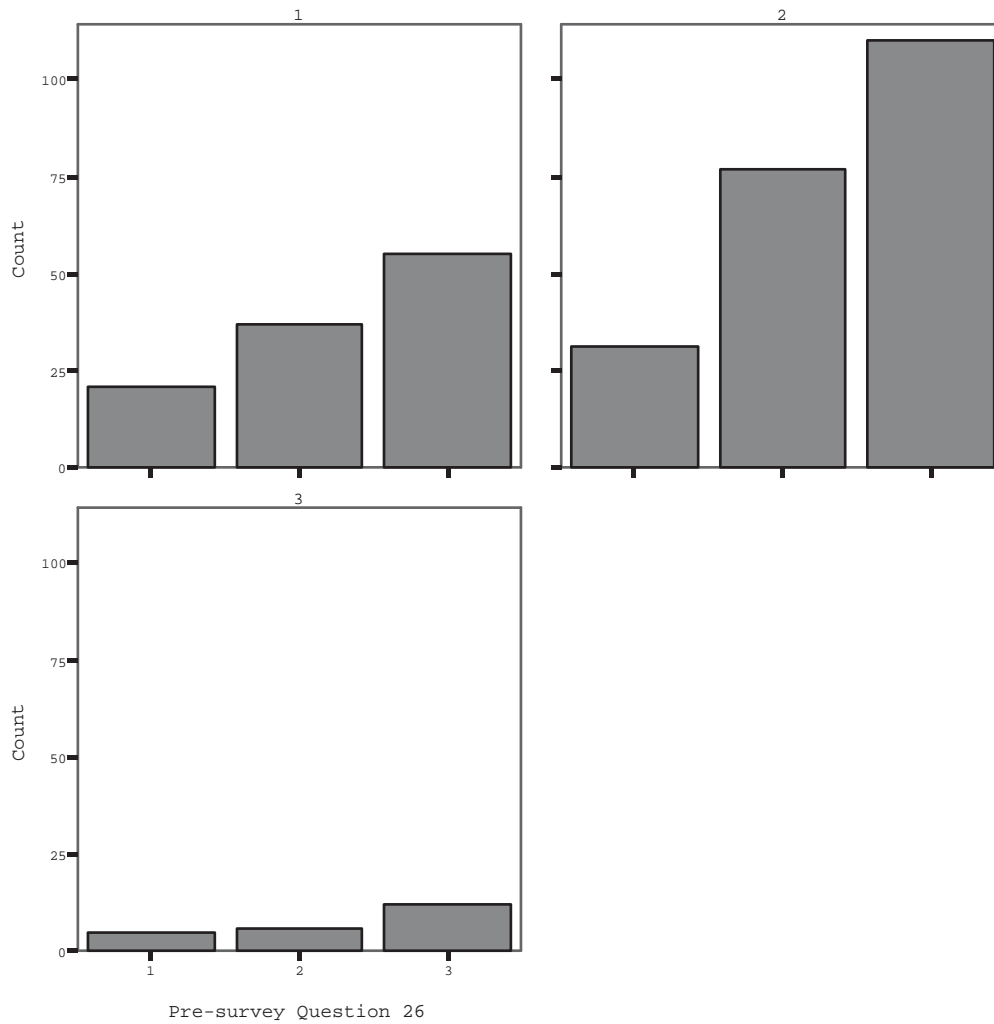
Figure B.26: Results from Pre-survey question 26, "What forces are acting upon the moon as it orbits the earth? 1) One - toward the earth, 2) Two - one toward the earth, one away from the earth, 3) Three - one toward the earth, one away from the earth, and one in the direction of the moon's motion". The correct answer is #1. Section numbers are indicated at the top of each graph (Section 3 is online).
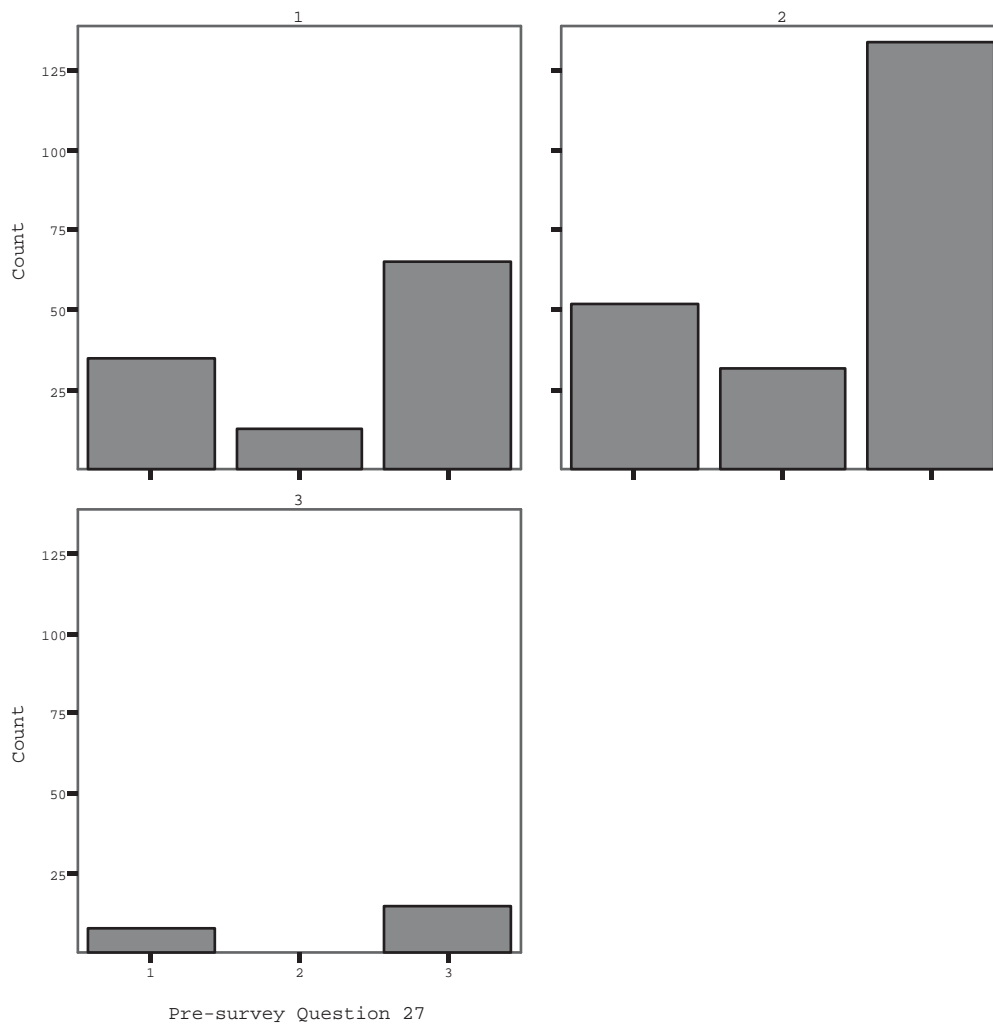
Figure B.27: Results from Pre-survey question 27, "A rocket ship is moving at near the speed of light. An astronaut turns on a bright lamp located at the front of the ship. What is true about the speed at which the light beam from the lamp is moving? 1) It is going at the speed of light plus the speed of the rocket, 2) It is going at the speed of the rocket, 3) It is moving at the speed of light". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).
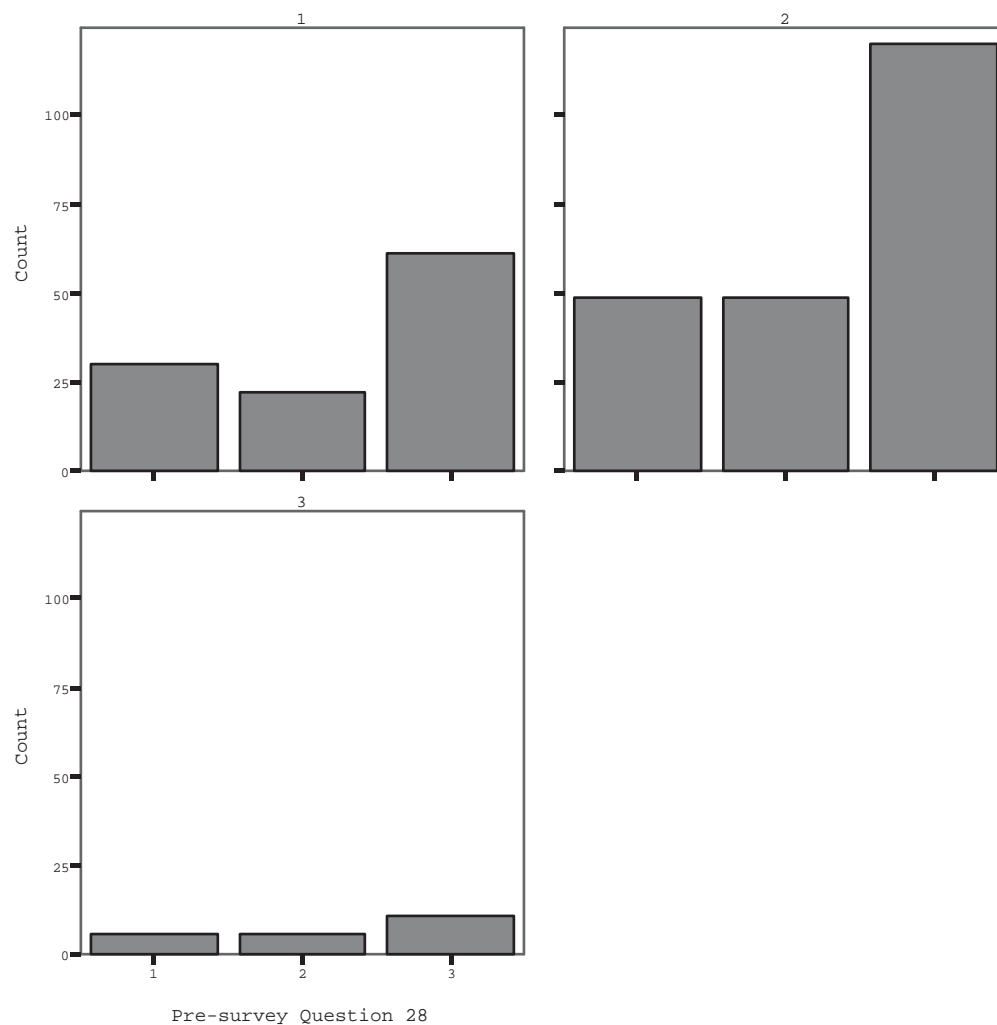
Figure B.28: Results from Pre-survey question 28, "Which of the following statements best describes the current, accepted model of the atom? 1) Electrons orbit around the nucleus in much the same way as planets orbit the sun, 2) Electrons are floating in a cloud of smaller, positively and neutrally charged particles, 3) Electrons can only be in certain energy levels called orbitals that exist about the nucleus". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).

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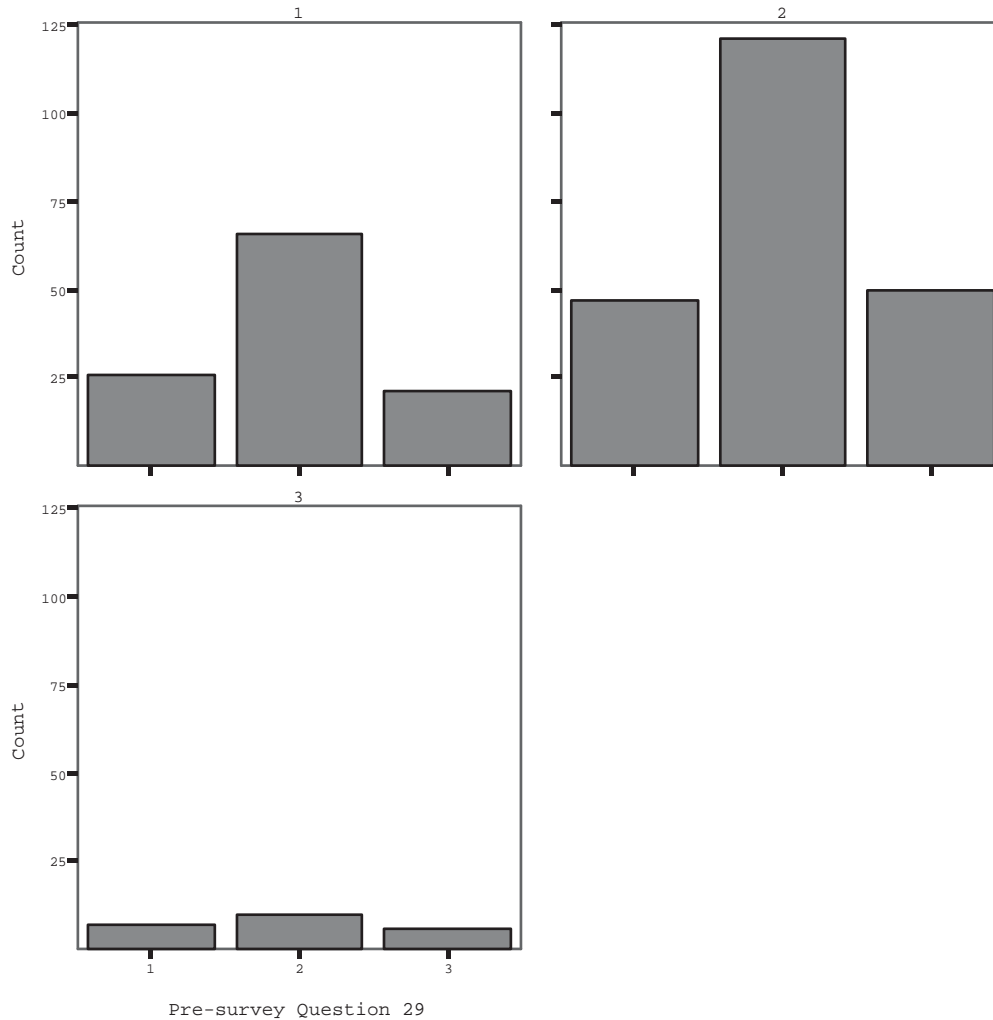
Figure B.29: Results from Pre-survey question 29, "Current engines are not 100% efficient (for example, car engines only use 25% of the energy released by burning gasoline). Which of the following is a true statement? 1) Engines with 100% efficiency are possible, but the technology to make them is not available, 2) Engines with 100% efficiency are not possible due to the Law of Increasing Disorder, 3) Engines with 100% efficiency are possible, but produce too much heat to be useful". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).
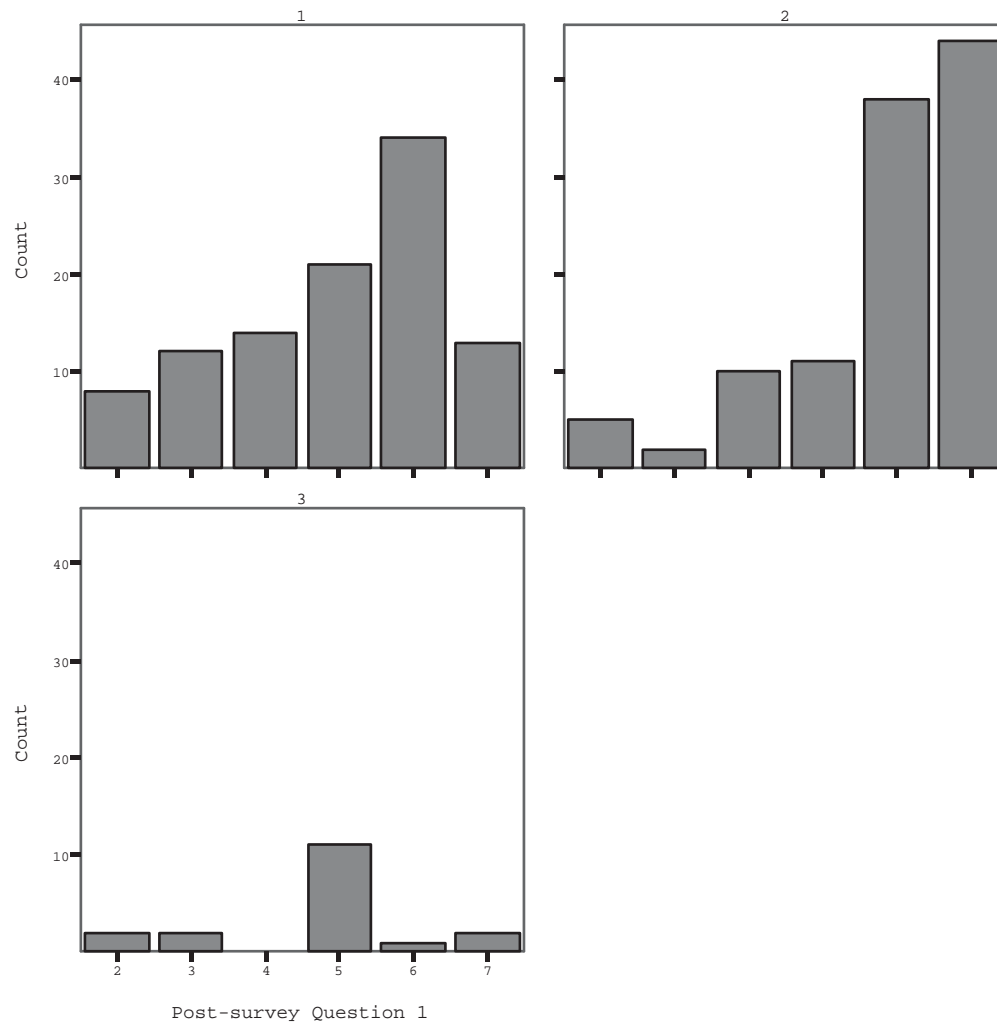
Figure B.30: Results from Post-survey Question 1, "Rate the instructor's overall teaching effectiveness." 1="Very Poor", 7="Excellent". Section numbers are indicated at the top of each graph (Section 3 is online).
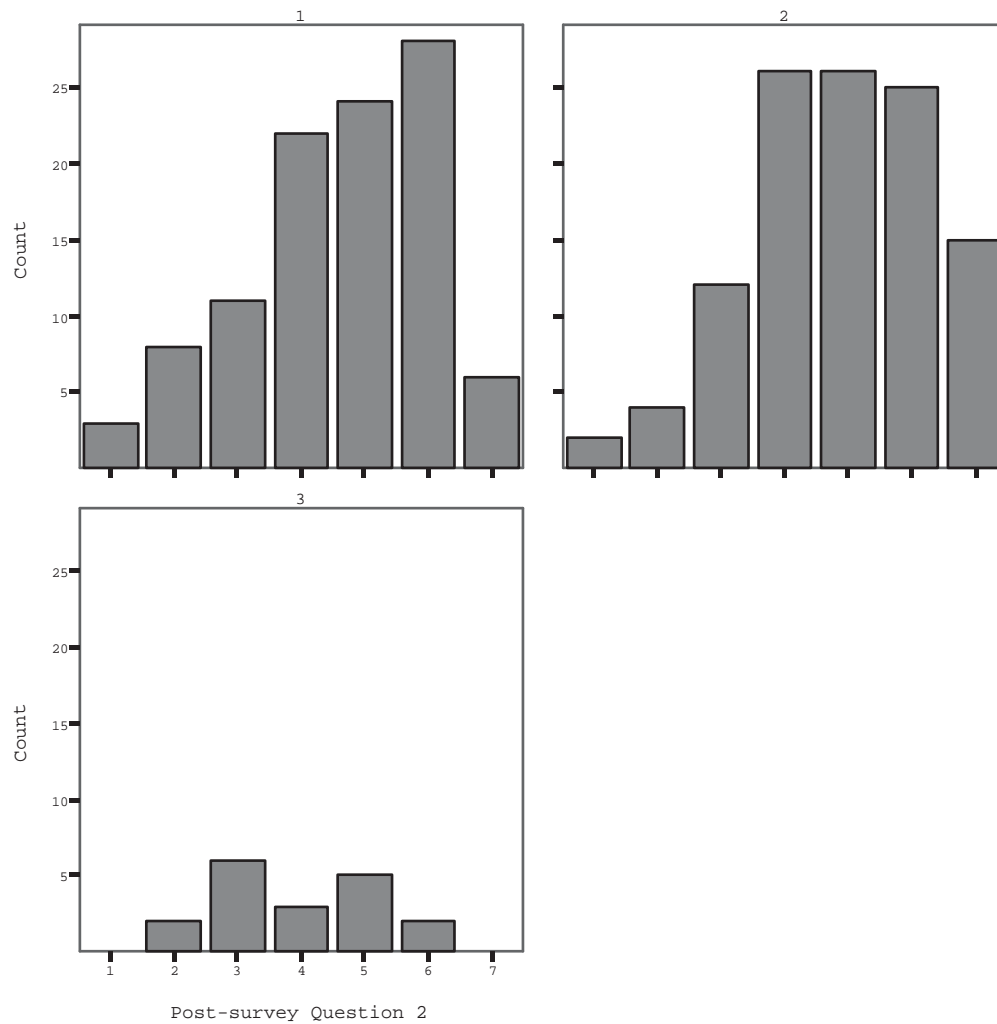
Figure B.31: Results from Post-survey Question 2, "Rate the overall quality of the course." 1="Very Poor", 7="Excellent". Section numbers are indicated at the top of each graph (Section 3 is online).
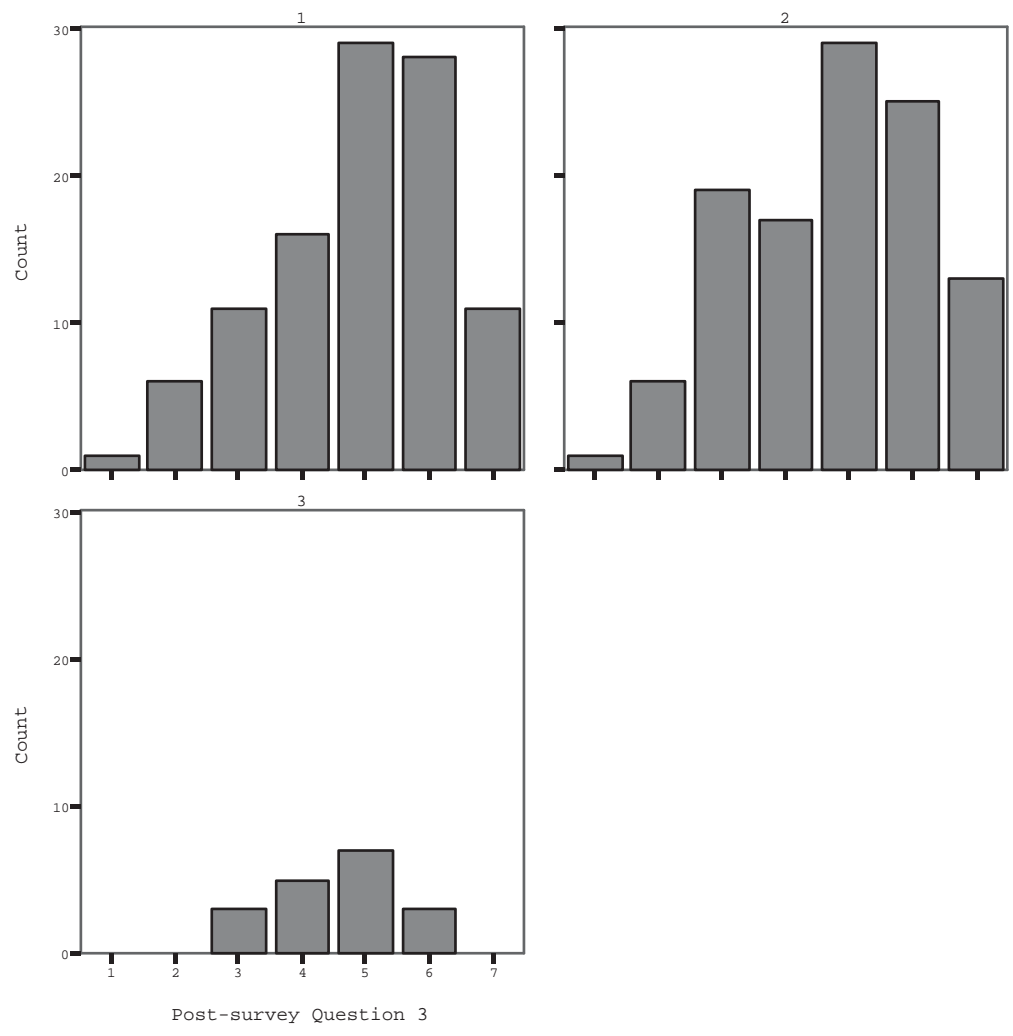
Figure B.32: Results from Post-survey Question 3, "Rate the amount you have learned in this course." 1="Very Poor", 7="Excellent". Section numbers are indicated at the top of each graph (Section 3 is online).

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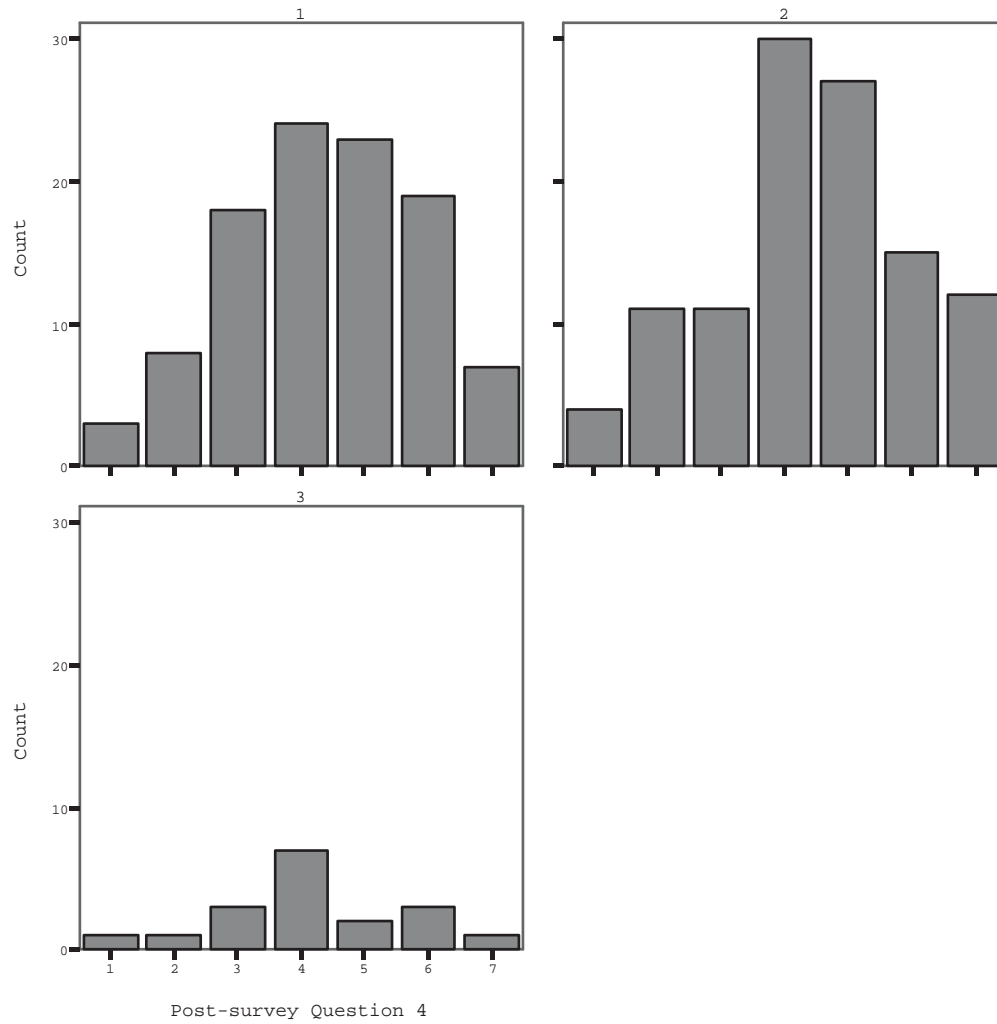
Figure B.33: Results from Post-survey Question 4, "The assignments helped me apply what I learned." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
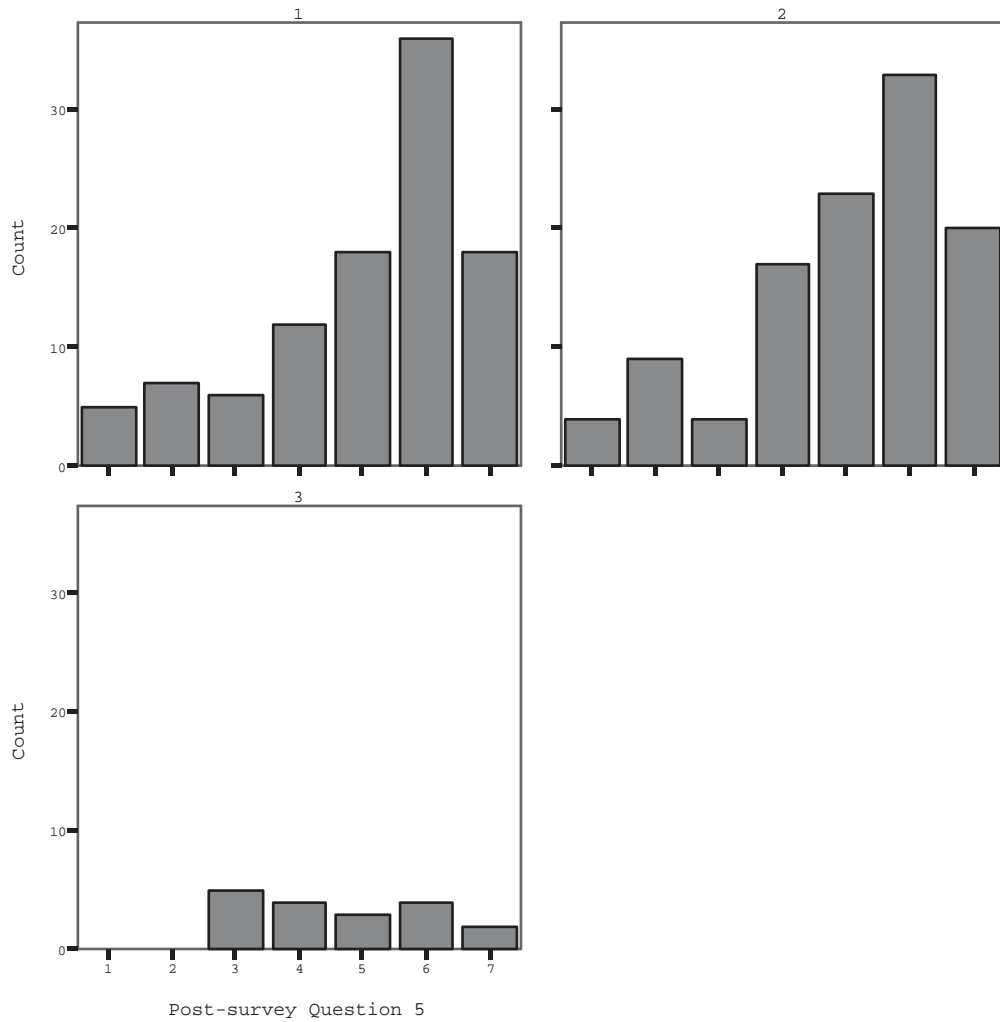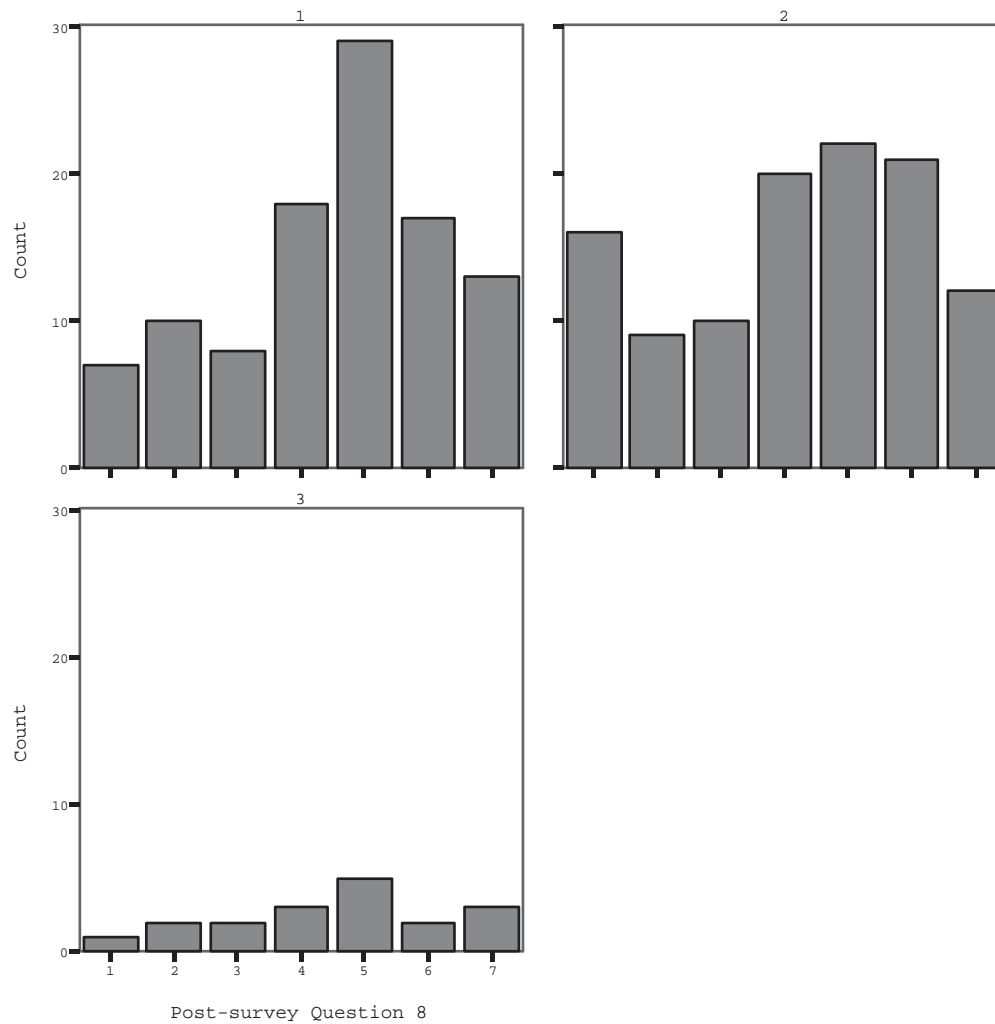
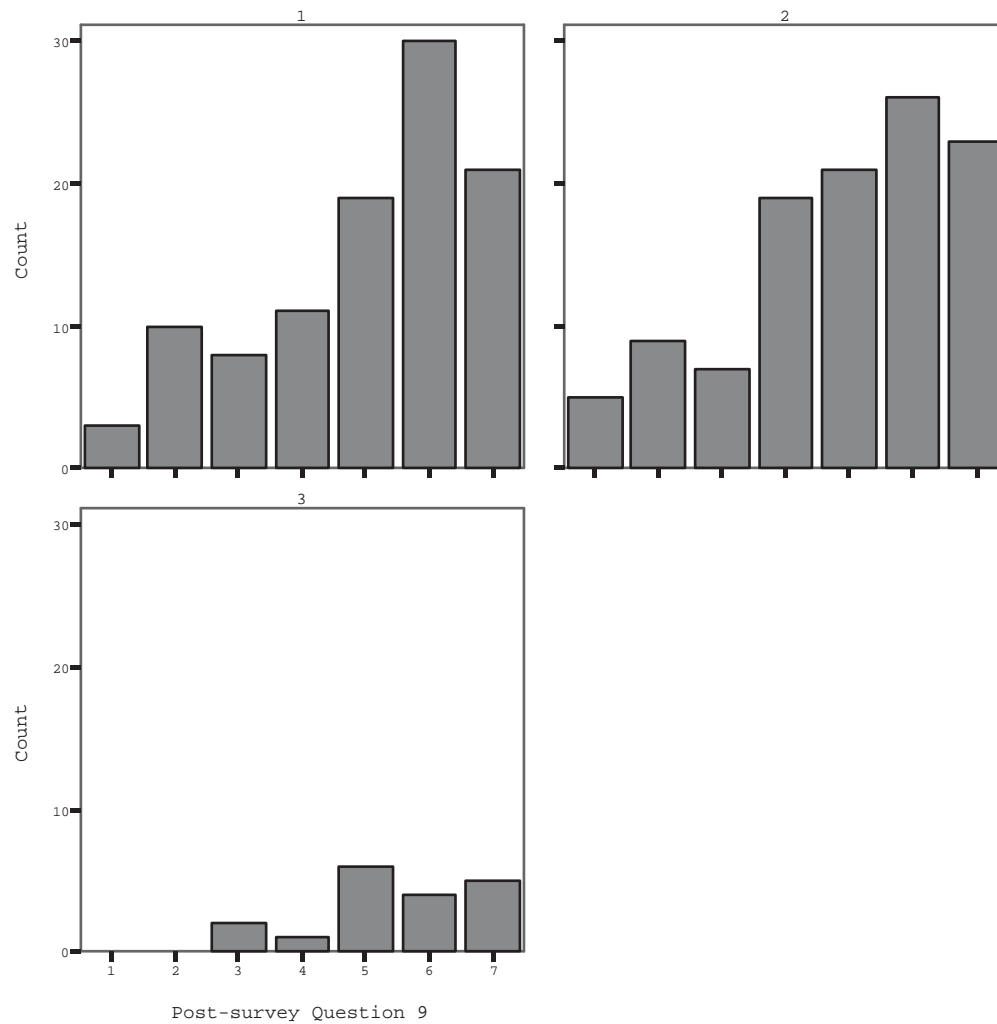Figure B.34: Results from Post-survey Question 5, "The amount of work required for this course was reasonable for the credit earned." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
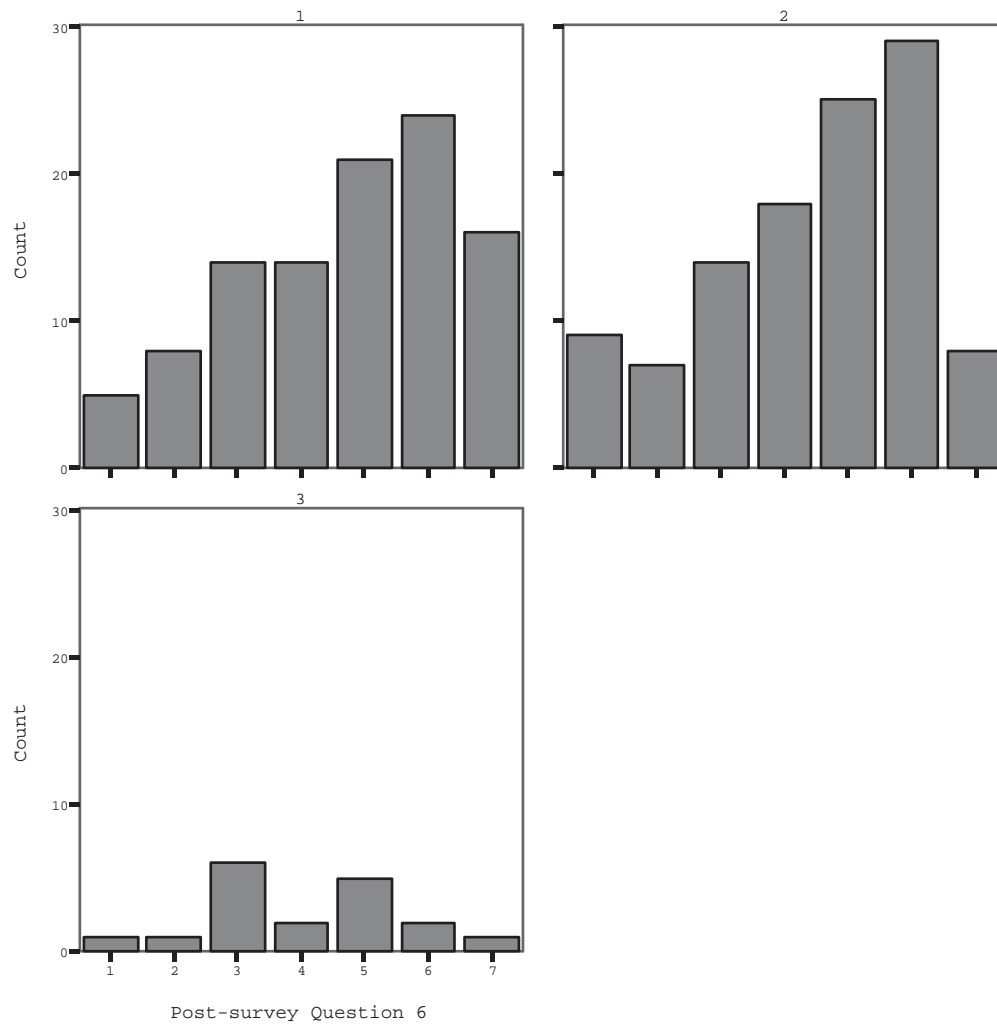
Figure B.35: Results from Post-survey Question 6, "The exams accurately measured what I learned in this course." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
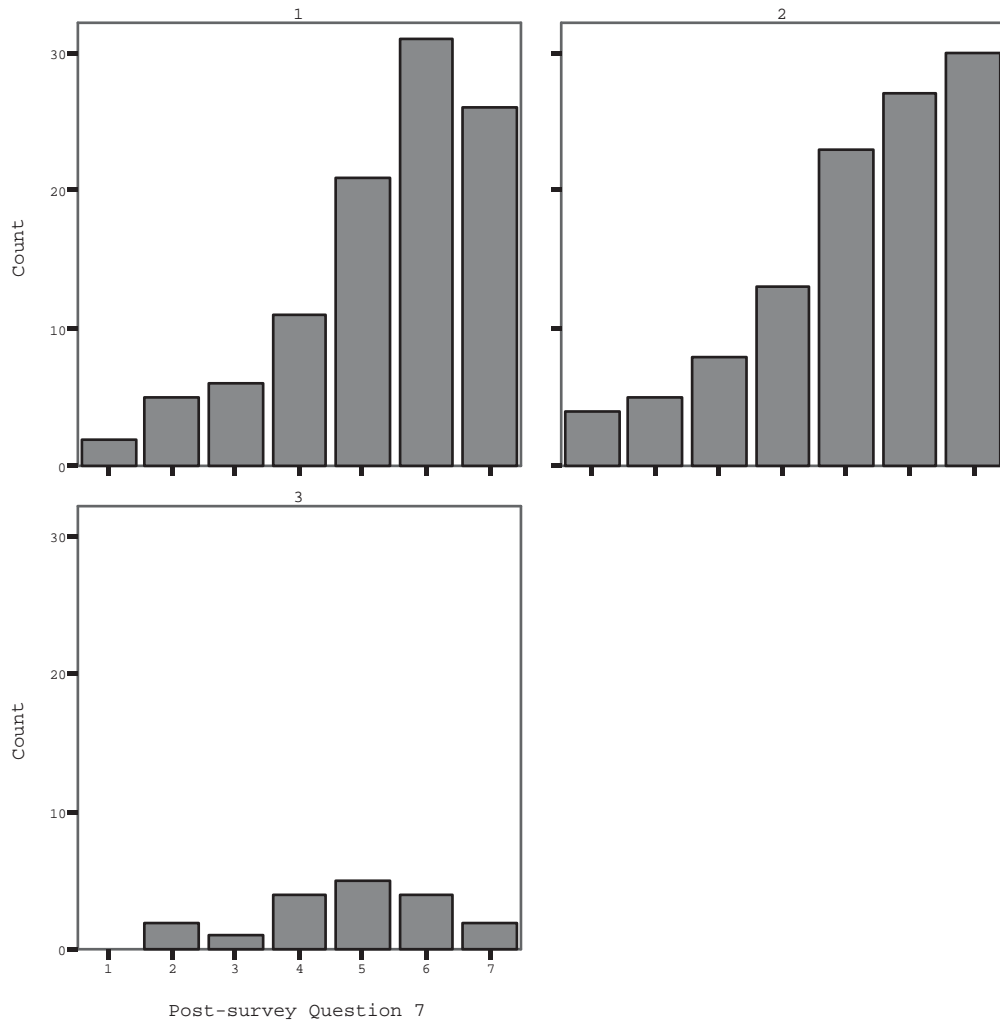
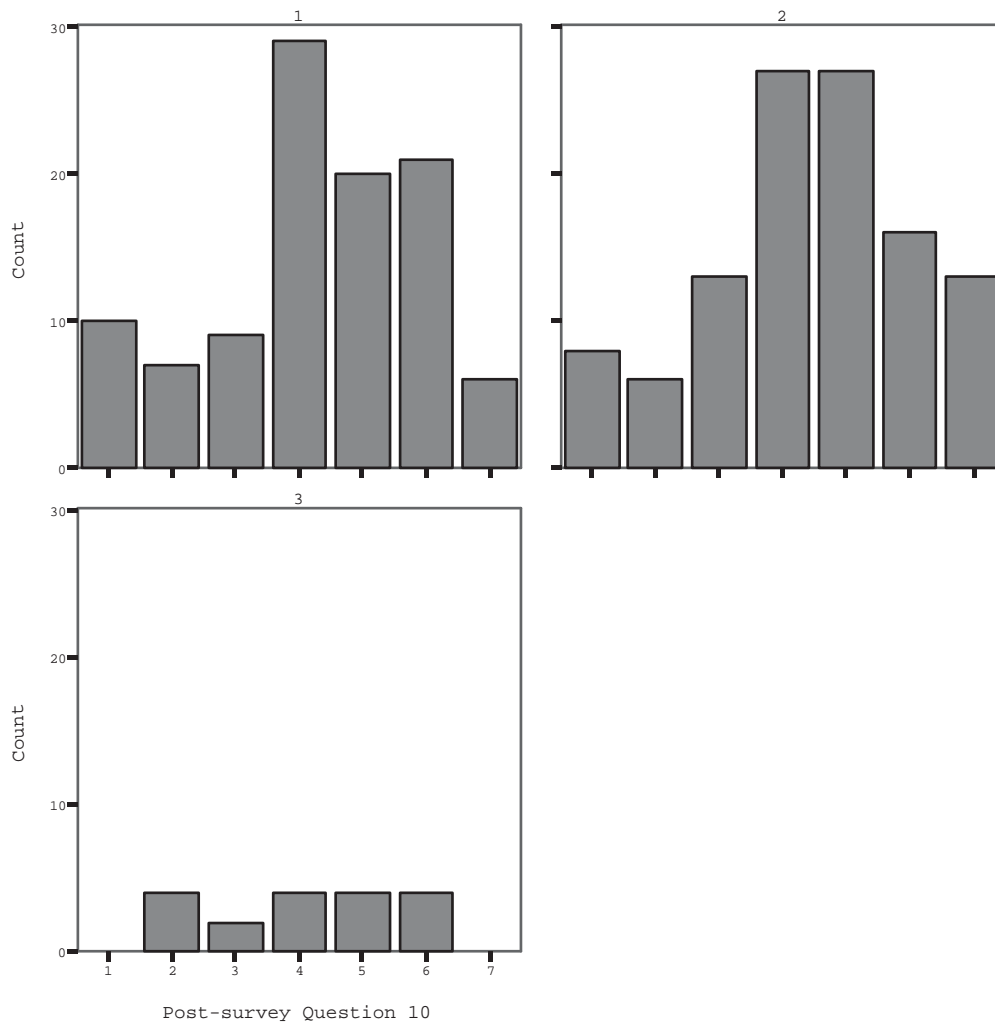Figure B.36: Results from Post-survey Question 7, "The course objectives were clear." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).

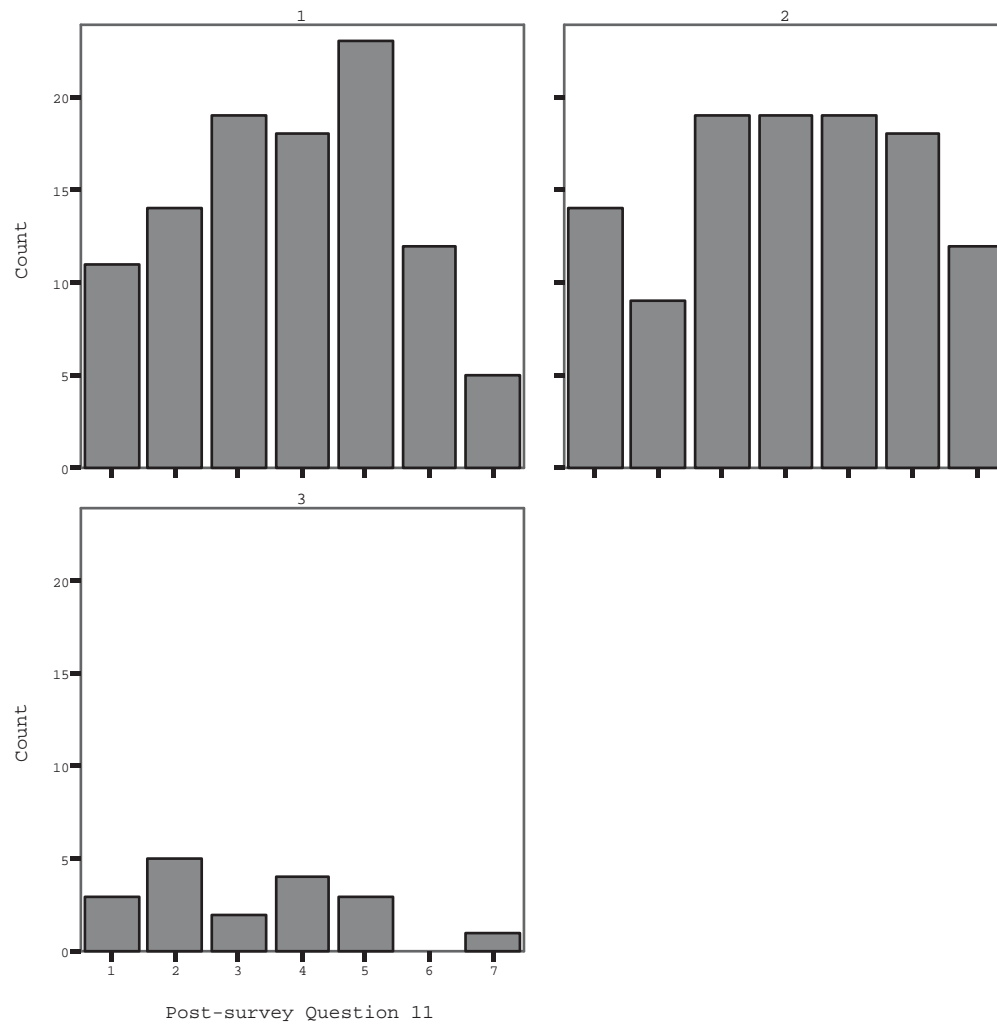Figure B.37: Results from Post-survey Question 8, "This course increased my interest in the subject area." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
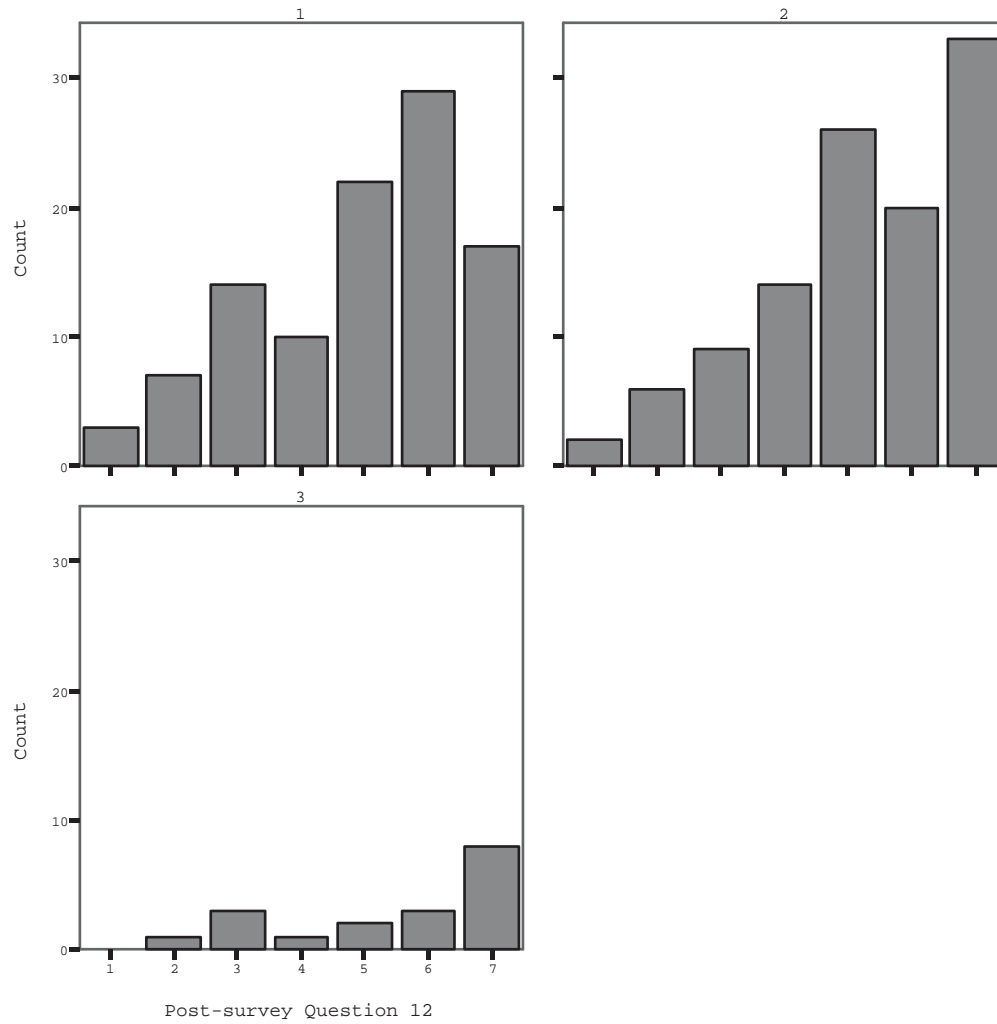
Figure B.38: Results from Post-survey Question 9, "The textbook was helpful in learning the course material." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.39: Results from Post-survey Question 10, "The instructor gave prompt feedback on student work." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
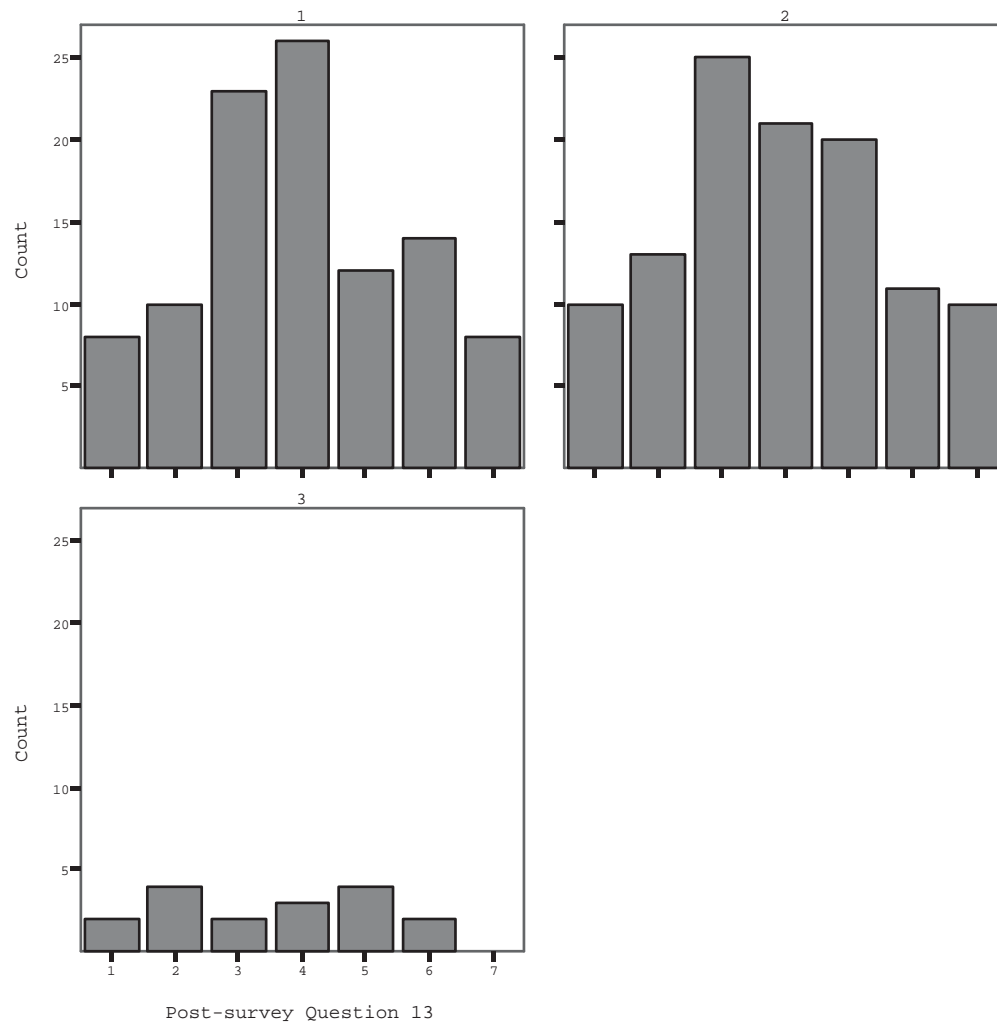
Figure B.40: Results from Post-survey Question 11, "I received constructive feedback on assignments and tests." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.41: Results from Post-survey Question 12, "The instructor showed a personal interest in students and their learning." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).

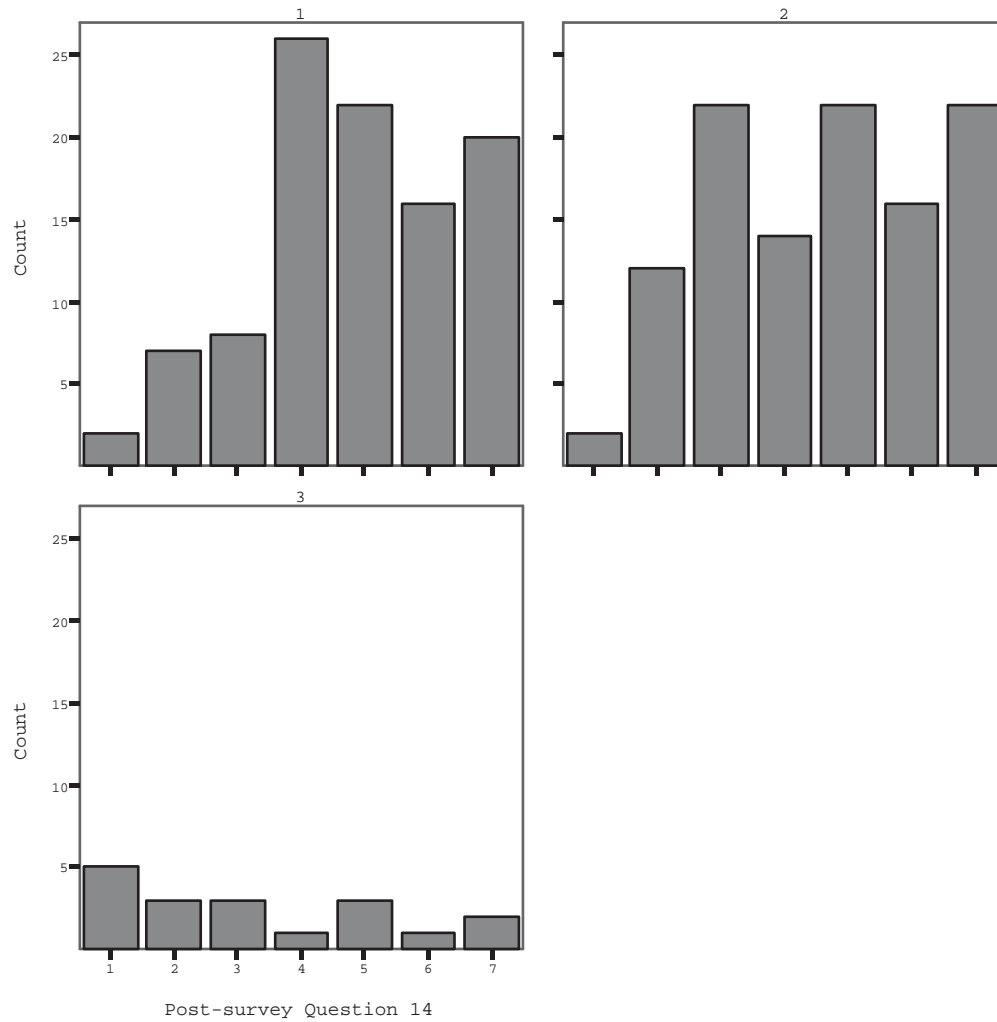Figure B.42: Results from Post-survey Question 13, "In this course, I would have liked more interaction with other students." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.43: Results from Post-survey Question 14, "The learning technology (e.g., internet, communication technology, and multimedia) worked well." 1="Strongly Disagree", 7="Strongly Agree". Section numbers are indicated at the top of each graph (Section 3 is online).
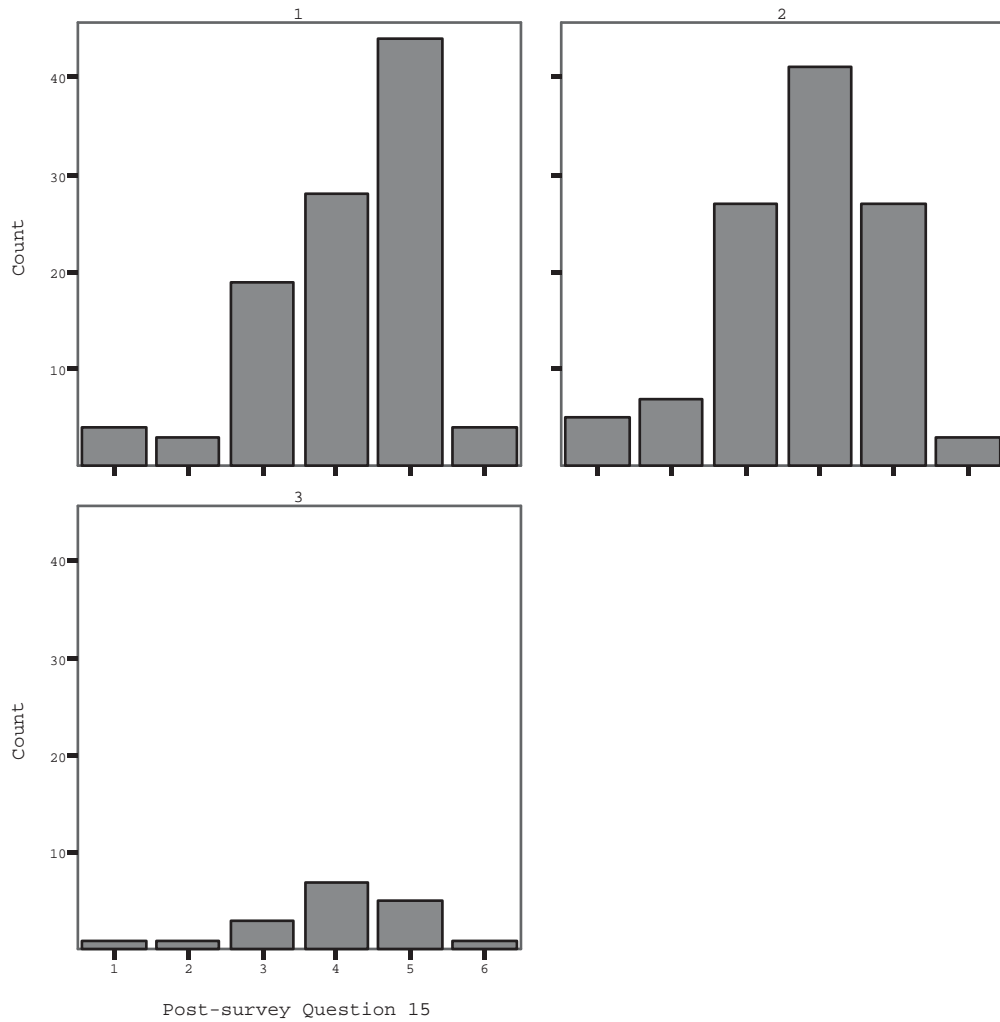
Figure B.44: Results from Post-survey Question 15, "Viewing videos embedded in the course". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
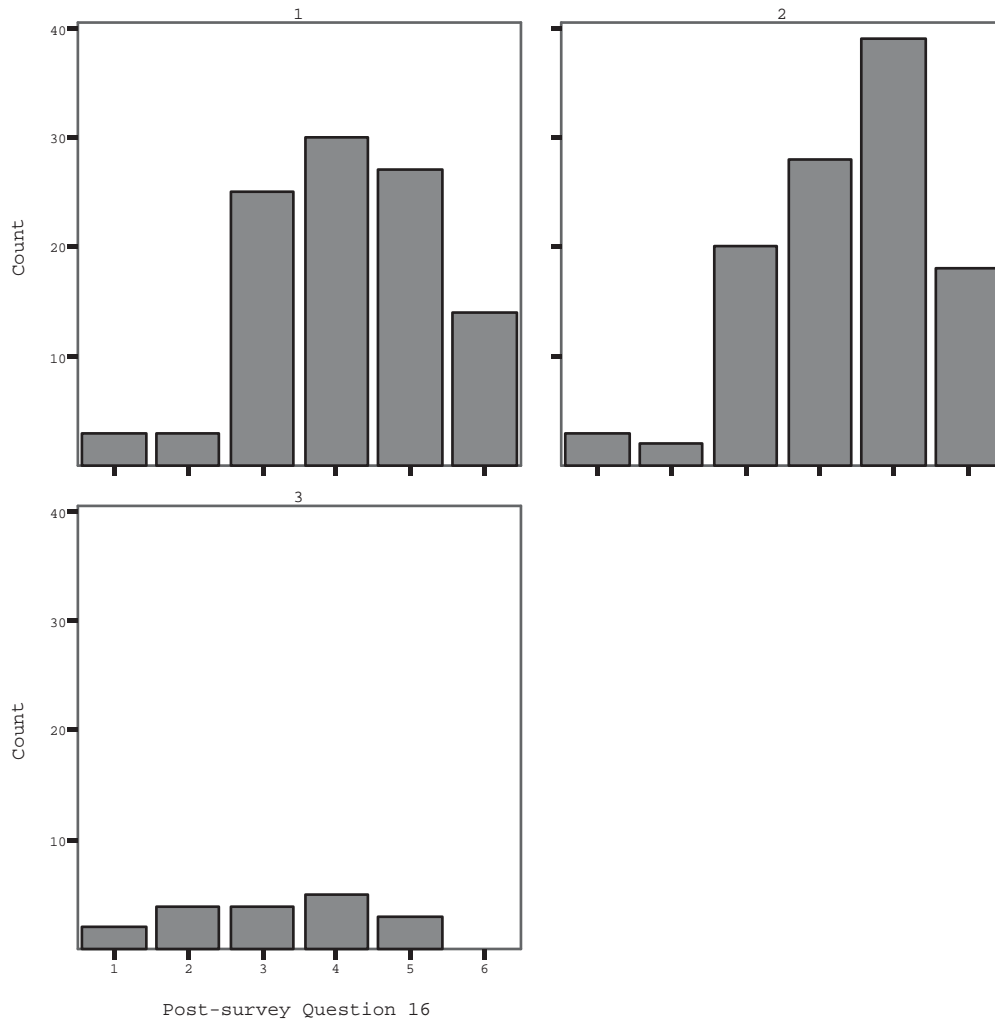
Figure B.45: Results from Post-survey Question 16, "Completing the lesson mastery questions". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
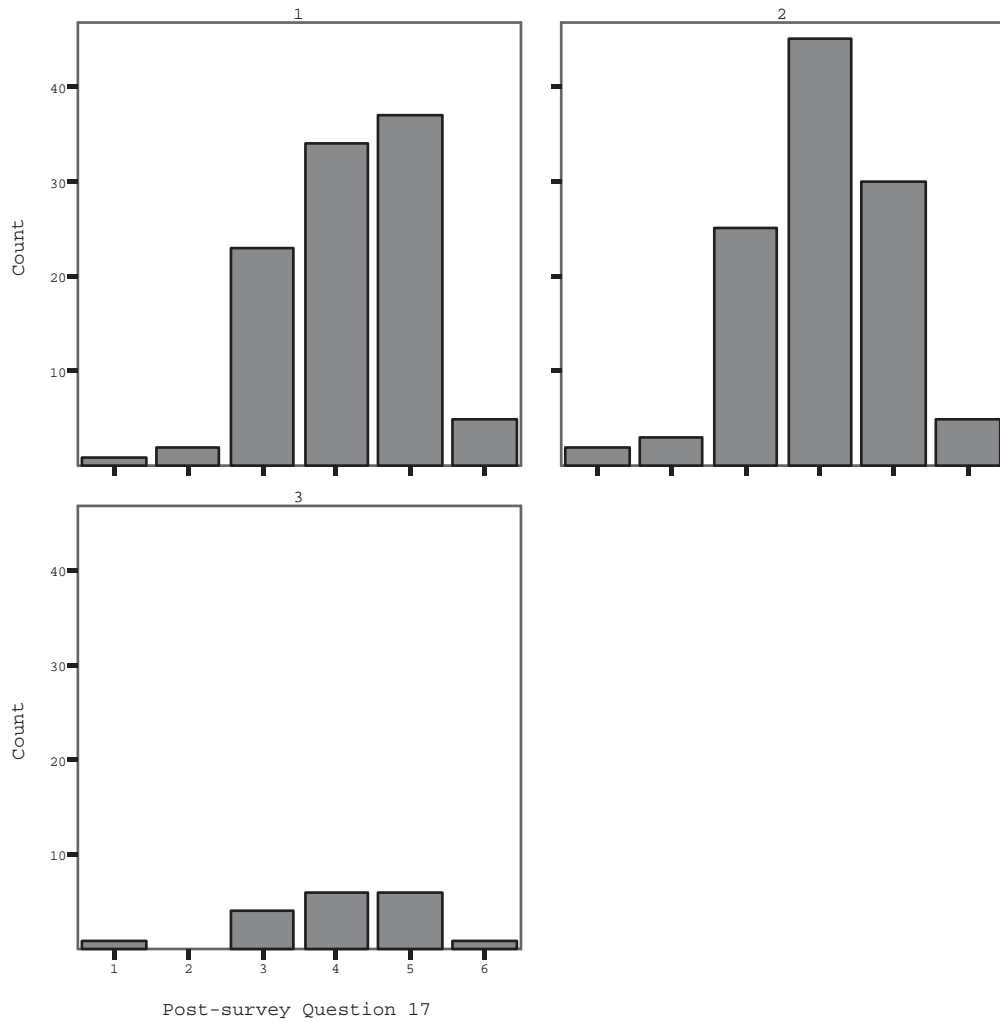
Figure B.46: Results from Post-survey Question 17, "Viewing animations embedded in the course". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
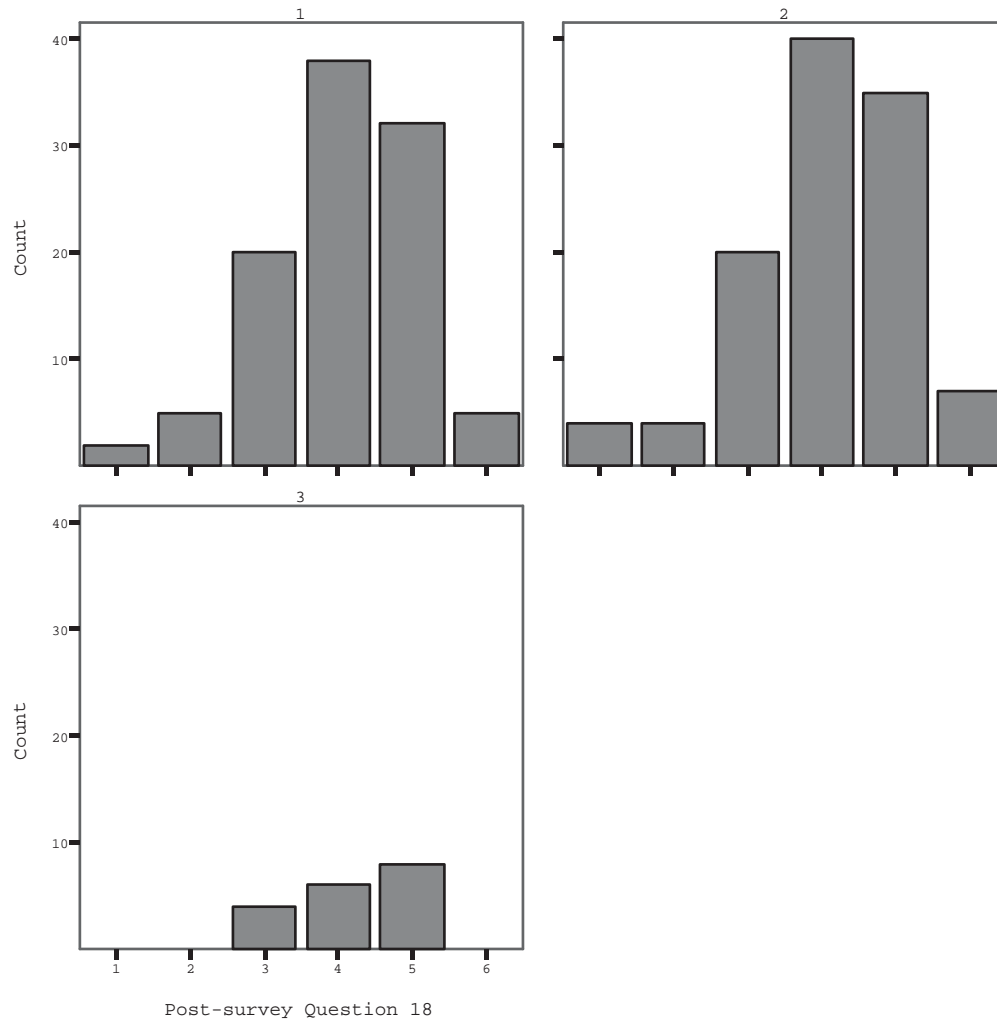
Figure B.47: Results from Post-survey Question 18, "Textbook readings". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.48: Results from Post-survey Question 19, "Multimedia feedback". 1= "Very Ineffective", 2= "Ineffective", 3= "Somewhat Effective", 4= "Effective", 5= "Very Effective", 6= "Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
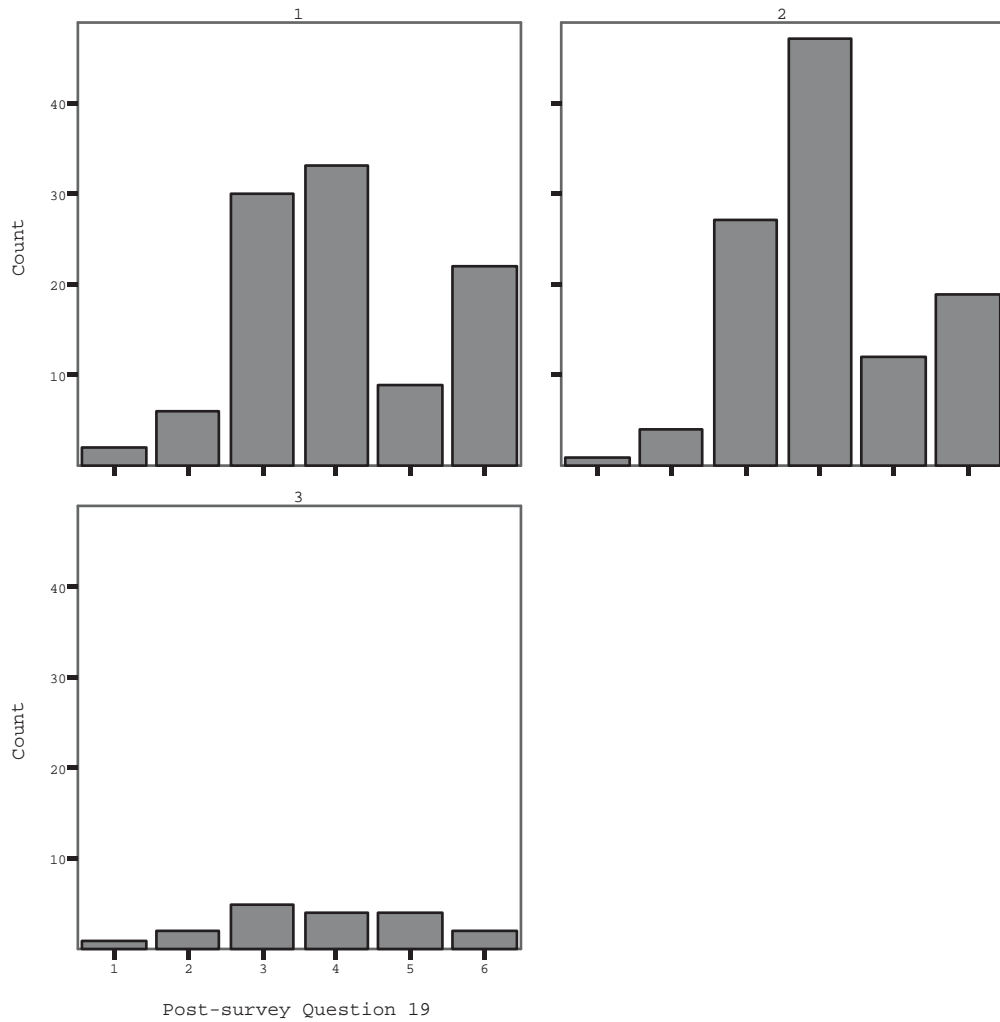
Figure B.49: Results from Post-survey Question 20, "Small group activities". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
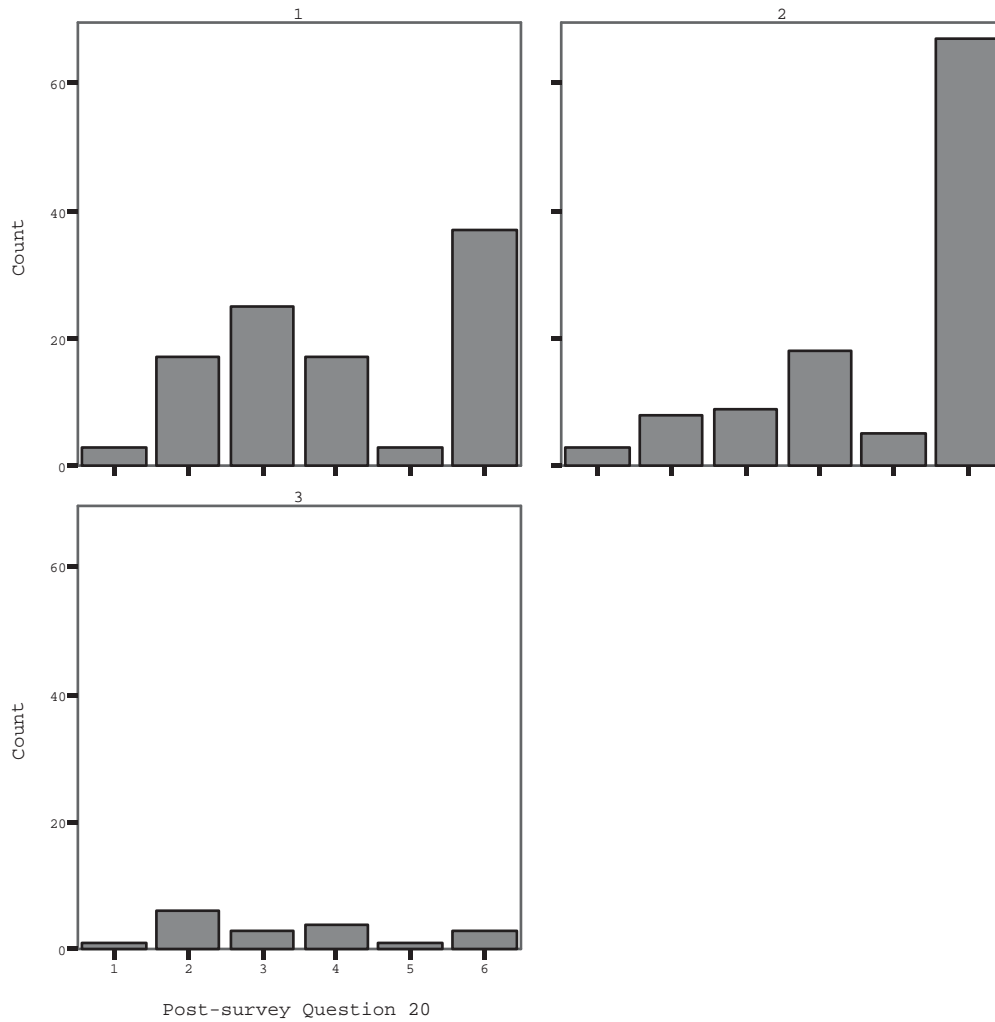
Figure B.50: Results from Post-survey Question 21, "Class meeting times". 1="Very Ineffective", 2="Ineffective", 3="Somewhat Effective", 4="Effective", 5="Very Effective", 6="Did Not Use". Section numbers are indicated at the top of each graph (Section 3 is online).
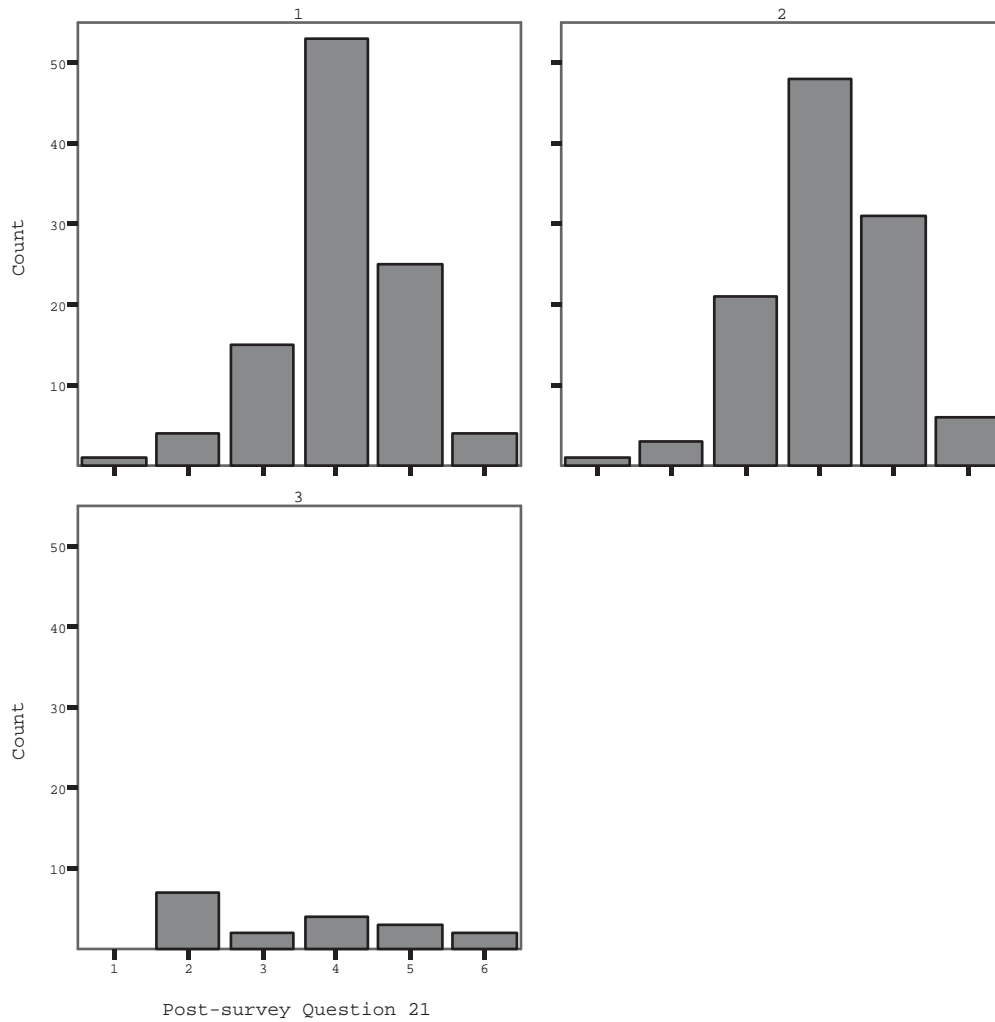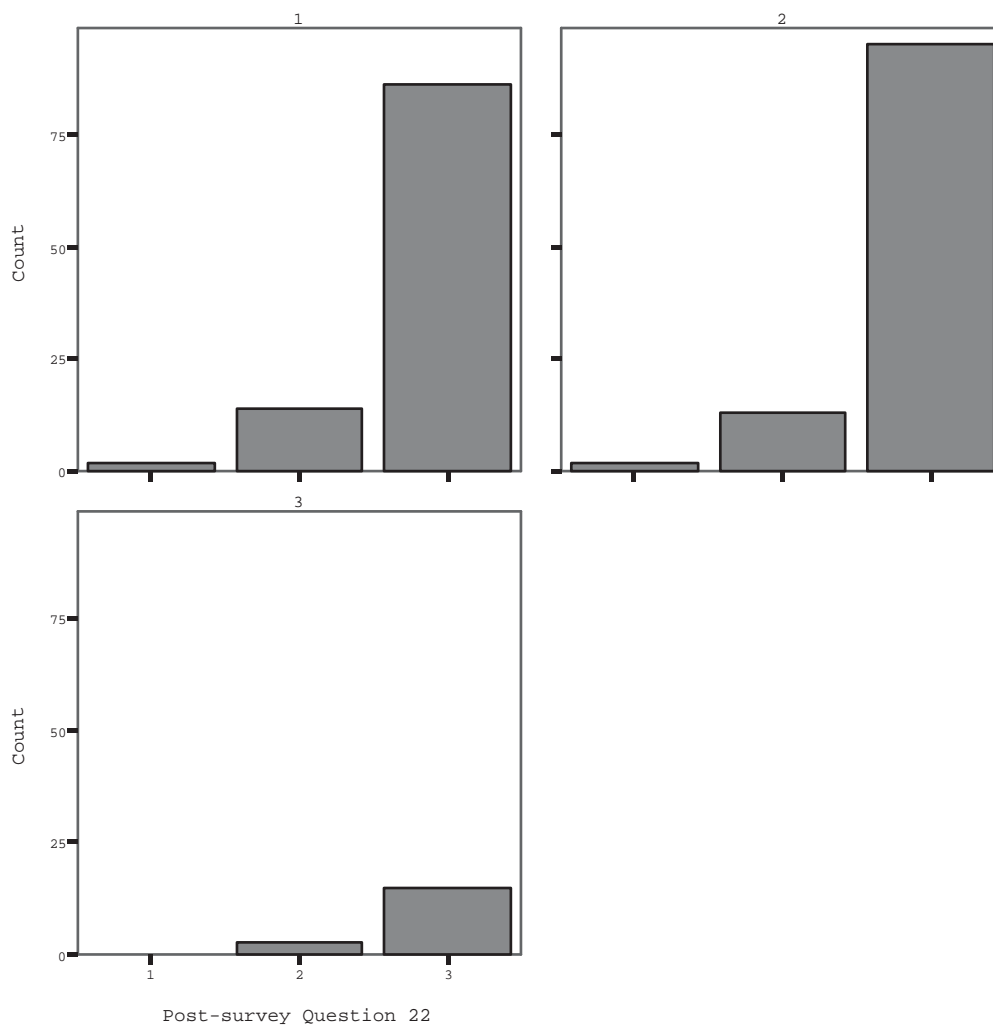
Figure B.51: Results from Pre-survey question 22, "A cannonball is launched from a cannon off of a high cliff. Which of the following statements is true? 1) The cannonball experiences no force after it leaves the cannon, 2) The cannonball's velocity doesn't change after it leaves the cannon, 3) The cannonball's acceleration and velocity are different". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).
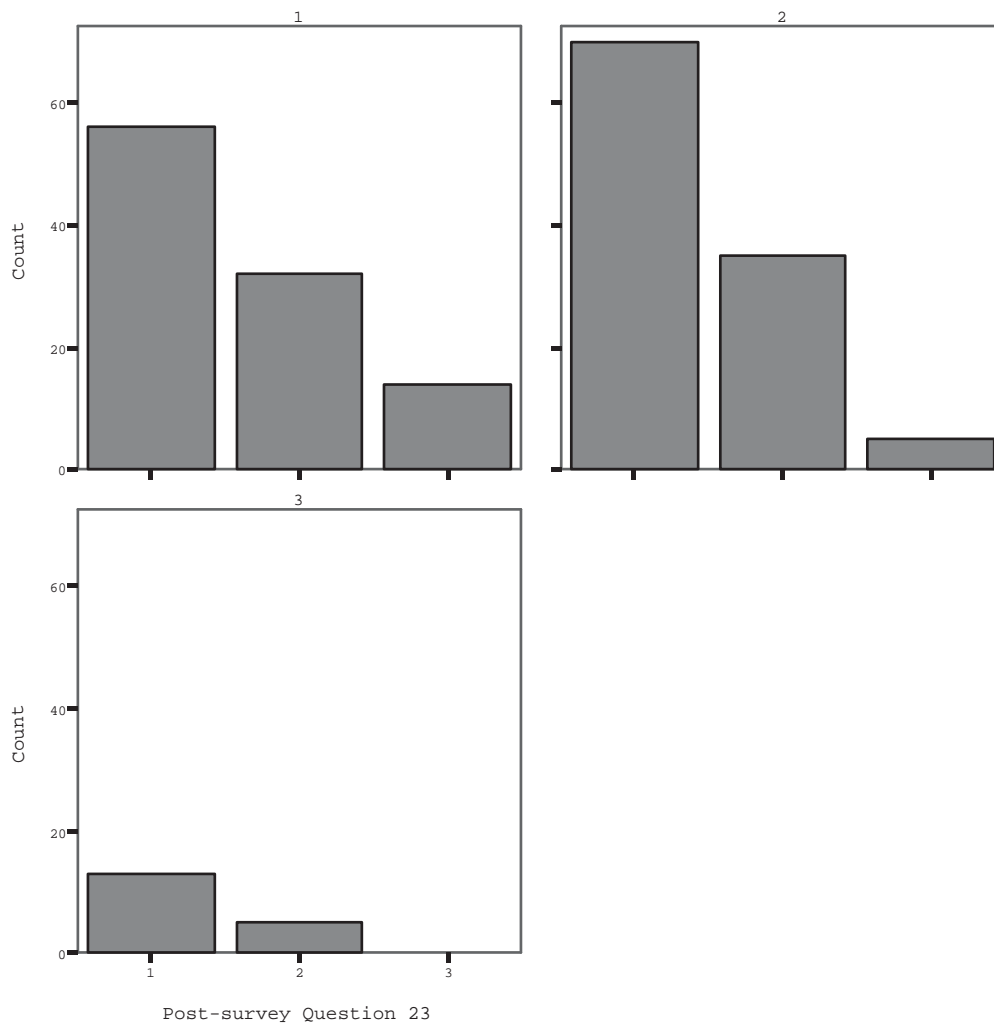
Figure B.52: Results from Pre-survey question 23, "A ball is thrown straight up in the air. At the top of its flight (highest point before falling back down), which of the following statements is true? 1) The acceleration of the ball is zero, 2) The acceleration of the ball is towards the earth, 3) The acceleration of the ball is away from the earth". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).

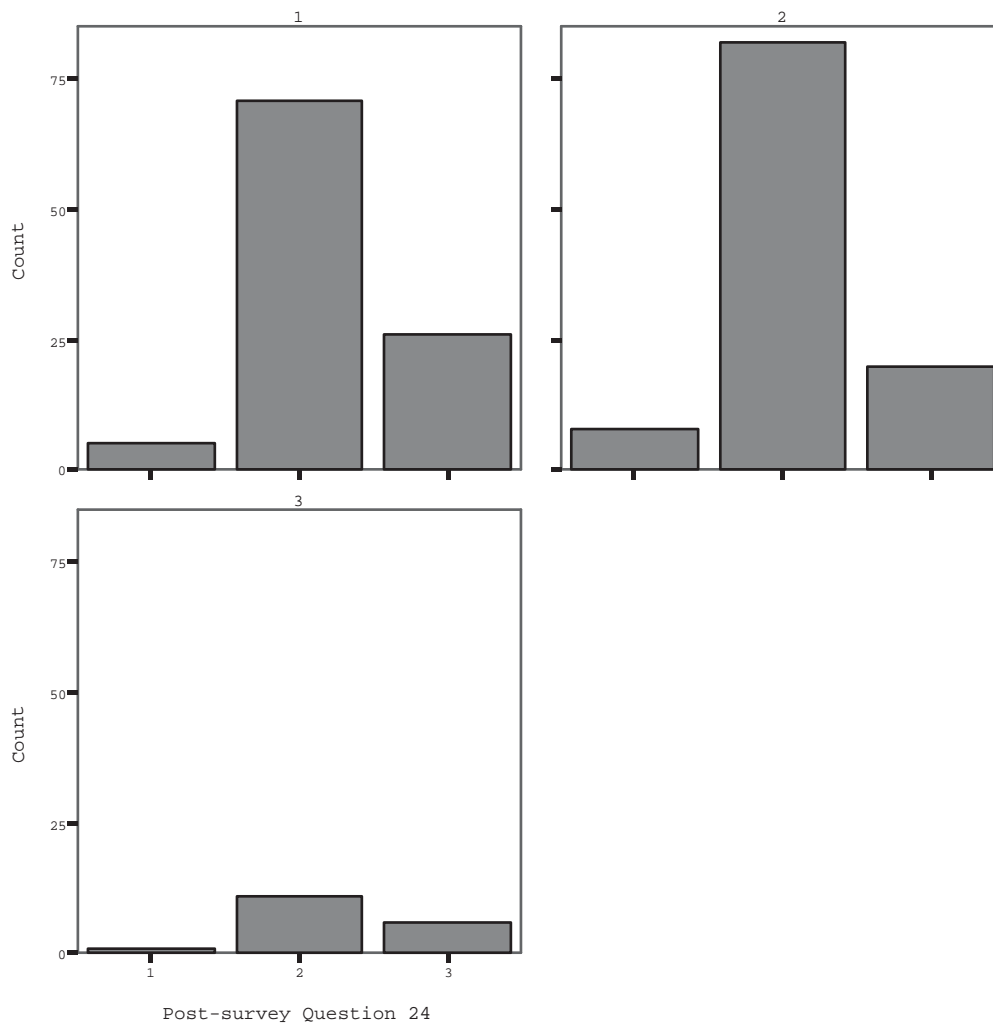Figure B.53: Results from Pre-survey question 24, "Which of the following statements about the nature of light is true? 1) Light is either a particle or a wave, but not both, 2) Light is both a wave and a particle, 3) Light can be a particle at one point in time and wave at another point in time". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).

Figure B.54: Results from Pre-survey question 25, "A cart on a frictionless track slides from a high point to a low one. What can be said about the total amount of energy it has at the low spot? 1) It is the same as the total energy it had at the top, 2) It is greater than the total energy it had at the top, 3) It is less than the total energy it had at the top". The correct answer is #1. Section numbers are indicated at the top of each graph (Section 3 is online).

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Figure B.55: Results from Pre-survey question 26, "What forces are acting upon the moon as it orbits the earth? 1) One - toward the earth, 2) Two - one toward the earth, one away from the earth, 3) Three - one toward the earth, one away from the earth, and one in the direction of the moon's motion". The correct answer is #1. Section numbers are indicated at the top of each graph (Section 3 is online).

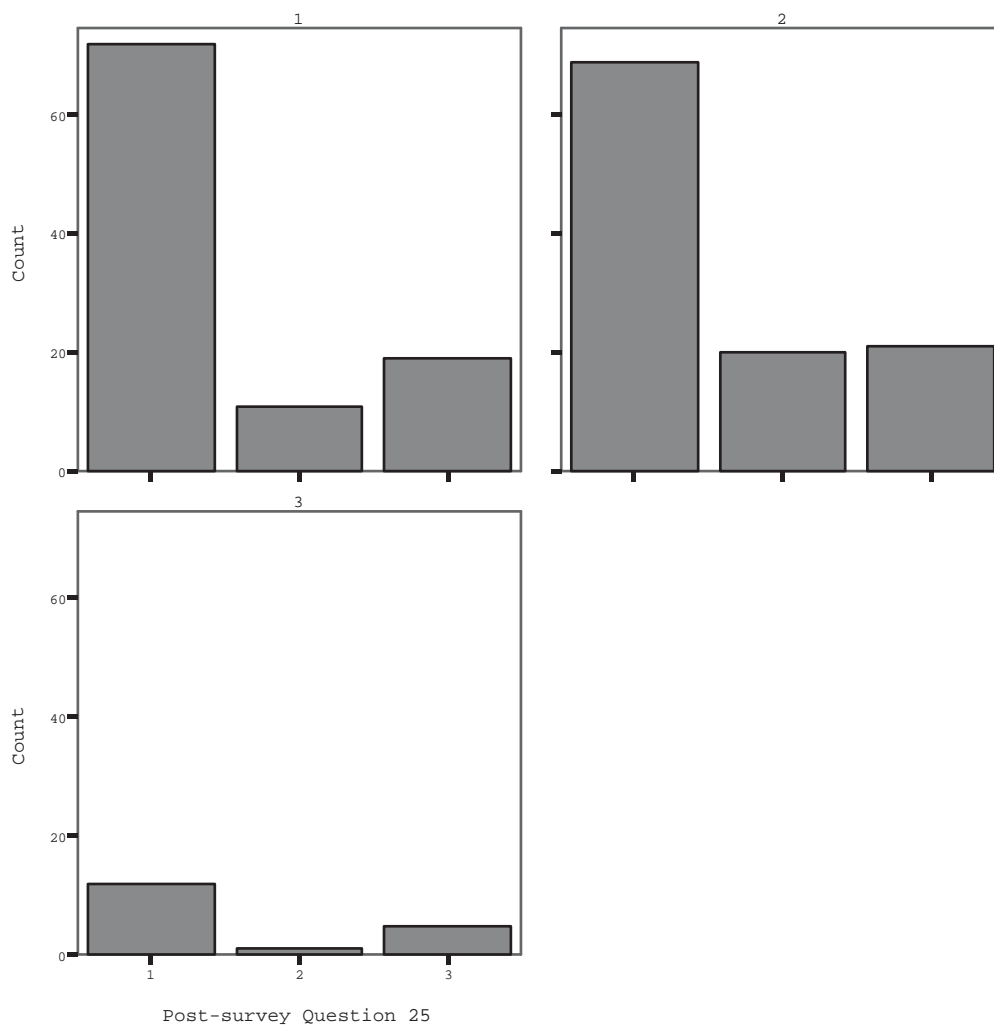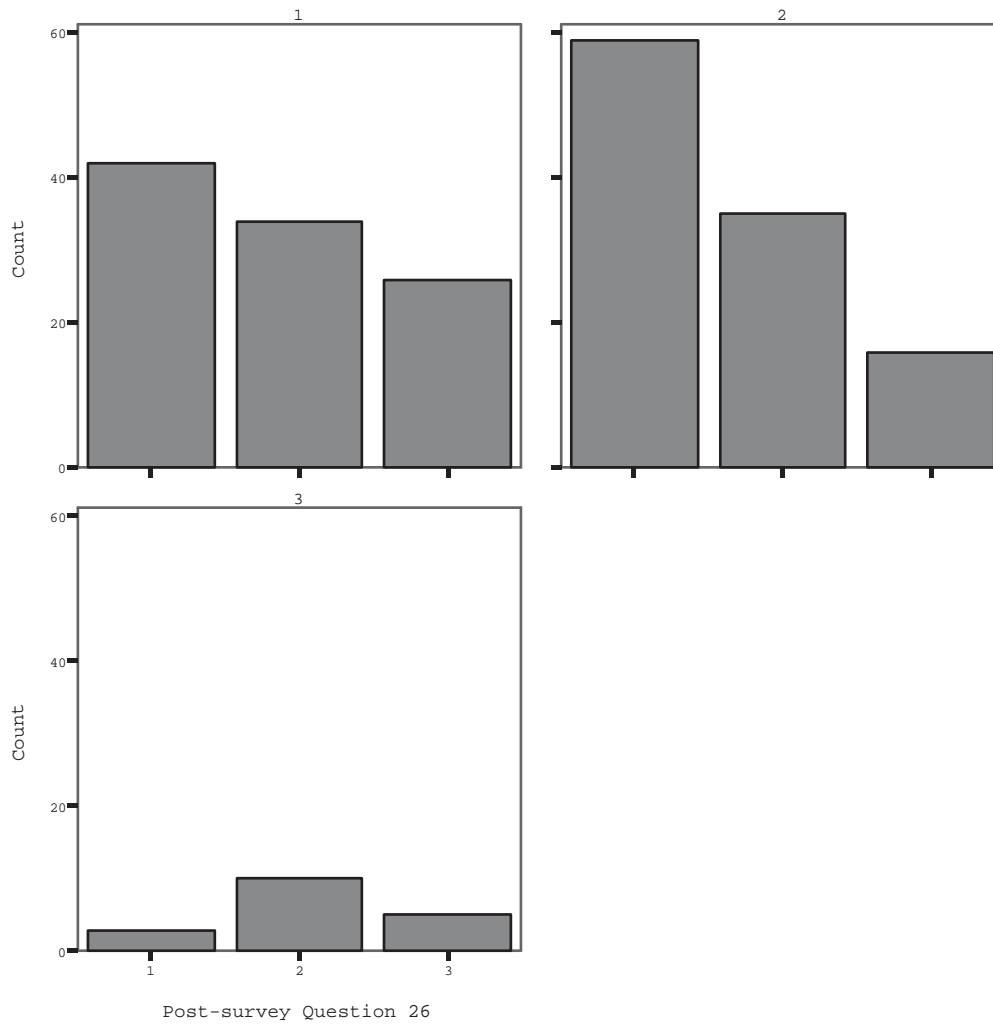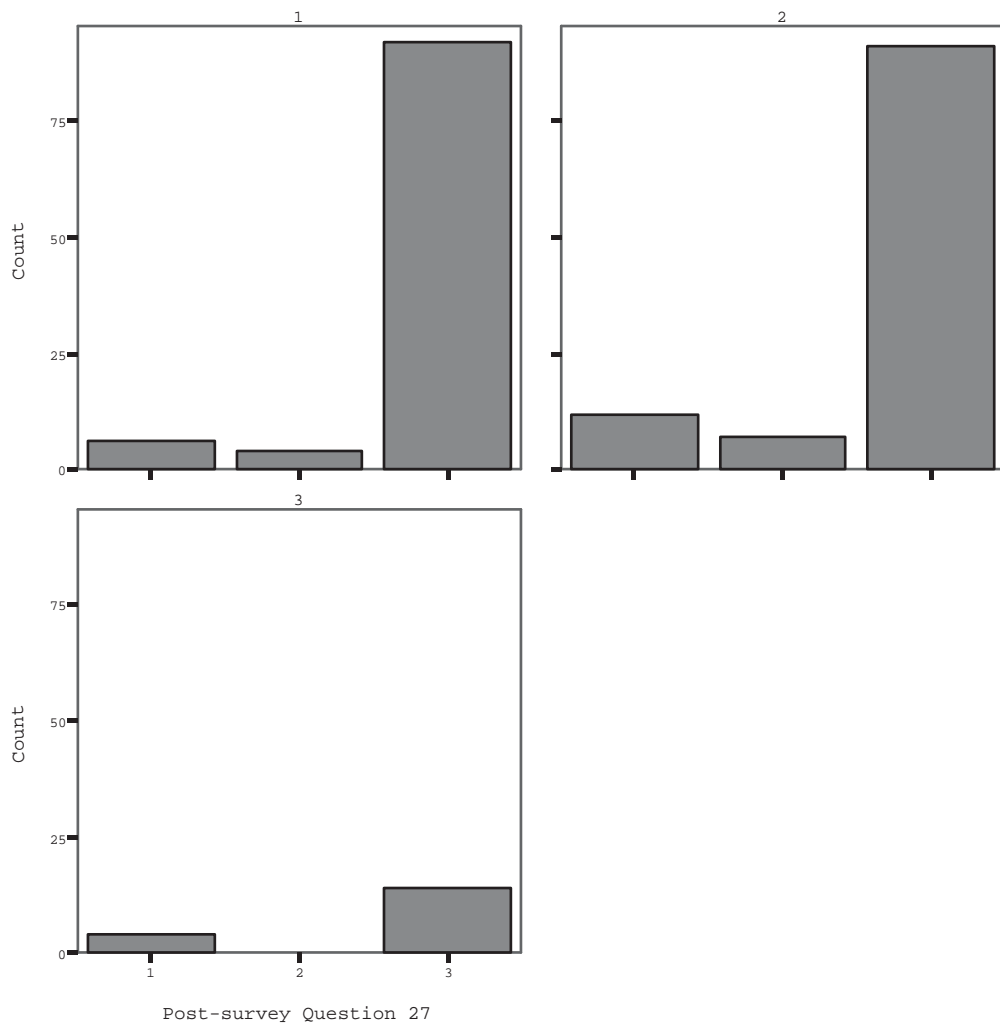Figure B.56: Results from Pre-survey question 27, "A rocket ship is moving at near the speed of light. An astronaut turns on a bright lamp located at the front of the ship. What is true about the speed at which the light beam from the lamp is moving? 1) It is going at the speed of light plus the speed of the rocket, 2) It is going at the speed of the rocket, 3) It is moving at the speed of light". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).
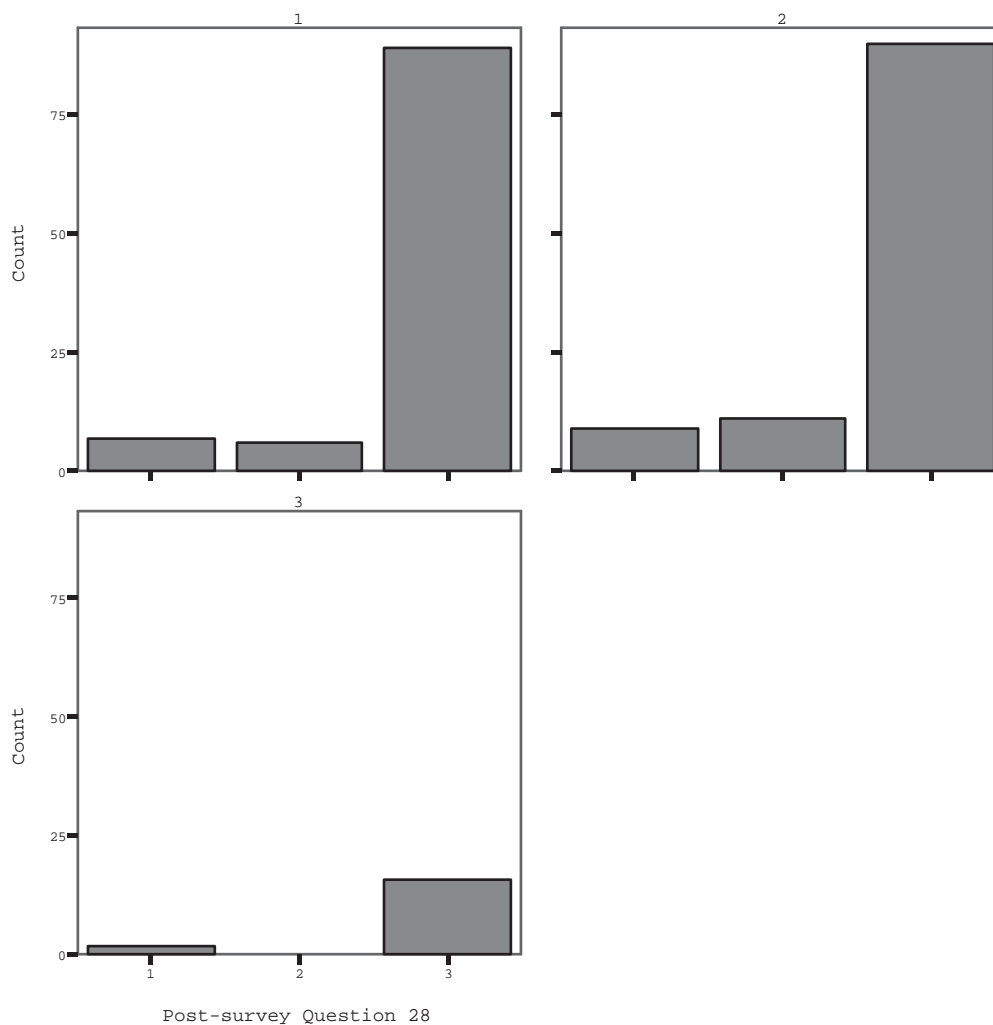
Figure B.57: Results from Pre-survey question 28, "Which of the following statements best describes the current, accepted model of the atom? 1) Electrons orbit around the nucleus in much the same way as planets orbit the sun, 2) Electrons are floating in a cloud of smaller, positively and neutrally charged particles, 3) Electrons can only be in certain energy levels called orbitals that exist about the nucleus". The correct answer is #3. Section numbers are indicated at the top of each graph (Section 3 is online).
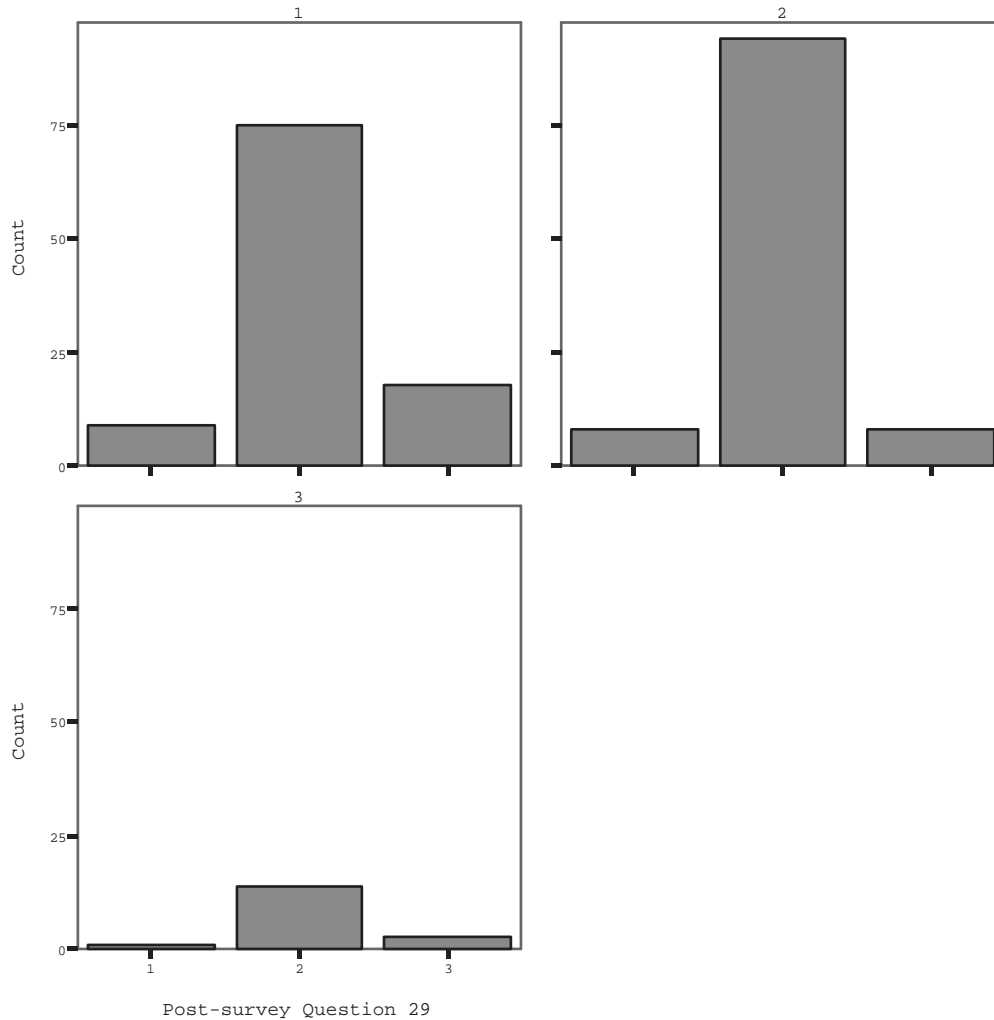
Figure B.58: Results from Pre-survey question 29, "Current engines are not 100% efficient (for example, car engines only use 25% of the energy released by burning gasoline). Which of the following is a true statement? 1) Engines with 100% efficiency are possible, but the technology to make them is not available, 2) Engines with 100% efficiency are not possible due to the Law of Increasing Disorder, 3) Engines with 100% efficiency are possible, but produce too much heat to be useful". The correct answer is #2. Section numbers are indicated at the top of each graph (Section 3 is online).

# Appendix C

# The Intentional Learning Orientation Questionnaire

Dr. Margaret Martinez has developed a learning style paradigm that identifies how students learn in a technology-oriented environment[26]. This paradigm allows designers and instructors to include content in web-based courses that "emulates the instructor's experienced, intuitive ability to recognize and respond to how individuals learn differently"[26].

The Intentional Learning Orientation paradigm focuses on how a student perceives his or her responsibility in the learning process. There are four main Learning Orientation classifications: Transforming, Performing, Conforming, and Resistant. I have summarized these orientations below. For detailed information, see the following references, found in the bibliography: [27, 28, 29, 30]. The following summaries should be sufficient to understand the results presented in the text.

## C.0.1  Learning Orientations

**Transforming learners**

Transforming Learners take full responsibility for learning and resist structured learning environments. They become frustrated when too many rules and guidelines are set forth, preferring their own methods and avenues of investigation. They are likely

to be interested in any field of study, regardless of interest area, major requirement, etc.

**Performing Learners**

Performing Learners are similar to Transforming Learners when the subject matter lies in areas of interest. Learning responsibility falls to the teacher or other authority figure if the subject matter is not directly related to goals and aspirations. A Performing Learner often will attempt to excel in classes related to interest areas. Any other opportunities for learning are either not sought or there is limited involvement or responsibility taken for learning.

**Conforming Learners**

Conforming Learners feel most comfortable with a set of instructions or guidelines that meet the expectations of a teacher or other authority figure. These learners typify the statement, "Tell me exactly what I need to do to get an A". Conforming Learners will do the minimum necessary to achieve goals set by others, but will work hard on personal goals.

**Resistant Learners**

Resistant Learners put almost all responsibility for learning on others, most often the teacher or other authority figure. If something is not learned or performance is below average, the resistant learner looks to external reasons. Often they balk at any kind of organized method or assignment requiring a step-by-step approach, preferring their own way of doing things.

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## C.0.2   Summary

These learning orientations do not suggest different levels of intelligence or IQ. They are indicators of how a student would prefer to learn, and where their perception of learning responsibility lies.

Table C.0.2 provides the numerical ranges associated with the classification levels of learning orientation.

| Classification | ILOQ Score |
|---|---|
| Transforming | 5.55-7.00 |
| Performing | 4.50-5.54 |
| Conforming | 3.75-4.49 |
| Resistant | 0-3.74 |

Table C.1: Numerical values corresponding to ILOQ classification.

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