The following project description and sample project is an example of the type of project that is completed by students using the Introduction to Statistical Investigations curriculum.

Project Description

How this factors into your overall grade

The project consists of a final paper with appendix and database as well as a PowerPoint presentation (all worth 75 points).

All assignments will be completed and turned by your group (of up to three people), not individually. You may work on this individually if you would like, but I don't encourage it.

Minimum requirements for project

The minimum requirements for the project are:

1. You conduct at least two tests of significance. (They don't need to be two different kinds of tests, but testing two different data sets---both related to your research topic.) You may use either our applets or another statistical software package.
2. You must gather the data yourself using a proper sampling or experimental design.
3. Your project should involve doing a literature review to investigate and present prior research work on the topic to both motivate and put your research in context.
4. You should NOT collect data using a survey, but you need to have your subjects actively involved in something. It would be nice for this to be some sort of an experiment, but doesn't have to be. I have listed a number of project ideas in this document.

Timeline of due dates for the project

On or before Friday, March 31: Submit a project proposal via email using guidelines below.
On or before April 6 or 7: You should have your data collected.
April 19 and 20/21: Project presentations in class
On or before Wednesday, April 26: Your paper, appendix and database are submitted through Moodle.

In your project proposal you should include:

1. The names of everyone in your group
2. Your research questions
3. What makes your research questions interesting or important
4. How you plan to gather your data
5. What variables will you collect
6. What sample size will you try to obtain
7. What statistical tests will you run

Before you collect your data!

As a first step to conducting your project you should write up an outline of what you plan to do. This should include your research question(s), your data gathering methods (how you plan to conduct the study, your proposed data analysis techniques (both descriptive and inferential), anticipated conclusions and limitations.

Practical Hint: A VERY common mistake on student final projects is to not clearly understand the connection between the data being gathered and the tests being run. For example, what type of data you collect (quantitative or categorical) impacts what analysis you will do. It is better to collect too much than too little.

Paper Guidelines

Your paper should consist of no more than 6 pages of concisely written single-spaced text (tables and graphs *are* included in the 6-page limit; however the appendix and database are not). Note: Fewer than six pages is NOT a problem! Some research write-ups will need more room than others. The text should be organized into sections as follows:

1. Title and Authors
2. Abstract
3. Background and Significance
4. Methods
5. Results
6. Discussion/Conclusions
7. References
8. Appendix (a separate file submission and thus not included in the 6 page limit)
9. Database (this can for quantitative data only a separate file submission and thus not included in the 6 page limit)

You should use a 12 pt font, single spaced. Each section should receive a heading.

1. Title and authors

Give an informative title to your research project and provide your group members names.

> *Assessment: Does the title give an accurate preview of what the paper is about? Is it informative, specific and precise?*

2. Abstract

The abstract provides a brief summary of the entire paper (background, methods, results and conclusions) in *no more than 200 words*. This allows you approximately 1 sentence (and likely no more than two sentences) summarizing each of the following sections. Typically, abstracts are the last thing you write.

> *Assessment: Are the main points of the paper described clearly and succinctly?*

3. Background and significance

In this section you are providing the background of the research area and arguing why it is interesting and significant. This section relies heavily on literature review (prior research done in this area and facts that argue why the research is important). This whole section should provide the necessary background leading up to a presentation (in the last few sentences of this section) of the research hypotheses that you will be testing/your study. Well-accepted facts and/or referenced statements should serve as the majority of content of this section. Typically, the background and significance section starts very broad and moves towards the specific area/hypotheses you are testing. You should cite your sources in this section. For example, *Roadrunners are known for their speed and ability to avoid allurements (Coyote, W. E. 1967).*

Assessment:

-Does the background and significance have a logical organization? Does it move from the general to the specific?

- Has sufficient background been provided to understand the paper? How does this work relate to other work in the scientific literature?

- Has a reasonable explanation been given for why the research was done? Why is the work important? Why is it relevant?

- Is the final paragraph a brief description of the hypothesis/goals of the paper?

4. Methods

a. *Data collection*. Explain how the data was collected/experiment was conducted. Additionally, you should provide information on the individuals who participated to assess representativeness. Non-response rates and other relevant data collection details should be mentioned here if they are an issue. However, you should not discuss the impact of these issues here---save that for the limitations section. **Make sure you include enough information in this section so I understand exactly what you did to collect your data.**

b. *Variable creation*. Detail the variables in your analysis and how they are defined (if necessary). For example, if you combined items to create a variable you should describe how. If you are talking about gender no further explanation is really needed.

c. *Analytic Methods*. Explain the statistical procedures that will be used to analyze your data. E.g. Boxplots are used to illustrate differences in GPA across gender and class standing. Correlations are used to assess the impacts of gender and class standing on GPA.

Assessment: Could the study be repeated based on the information given here? Is the material organized into logical categories (like the ones above)?

5. Results

Typically, results sections start with descriptive statistics, e.g. what percent of the sample is male/female, what is the mean GPA overall, in the different groups, etc. Figures can be nice to illustrate these differences! However, information presented must be relevant in helping to answer the research question(s) of interest. Typically, inferential statistics (tests of significance and confidence intervals) come next. DO NOT GIVE SOFTWARE OUTPUT OR APPLET SCREENSHOTS HERE UNLESS THEY ARE

APPROPRIATE GRAPHS! This should look like a peer-reviewed journal article results section. **Tables and figures should be labeled, embedded in the text, and referenced appropriately.** The results section typically makes for fairly dry reading. It does not explain the impact of the findings, it merely highlights and reports statistical information.

Assessment:

- Is the content appropriate for a results section? Is there a clear description of the results?
- Are the results/data analyzed well? Given the data in each figure/table is the interpretation accurate and logical? Is the analysis of the data thorough (anything ignored?)
- Are the figures/tables appropriate for the data being discussed? Are the figure legends and titles clear and concise?

6. Discussion/Conclusions

Restate your objective and draw connections between your analyses and objective. In other words, how did (or didn't) you answer/address your objective. Place these all in the larger scope of previous research on your topic (i.e. what you found from the literature review), that is, how do your findings help the field move forward? Talk about the limitations of your findings and possible areas for future research to better investigate your research question. End with a concluding sentence or two that summarizes your key findings and impact on the field.

Assessment:
- Does the author clearly state whether the results answer the question (support or disprove the hypothesis)?
- Were specific data cited from the results to support each interpretation? Does the author clearly articulate the basis for supporting or rejecting each hypothesis?
- Does the author adequately relate the results of the current work to previous research?

7. References

Assessment: Are the references appropriate and of adequate quality? Are the references citied properly (both in the text and at the end of the paper)?

8. Appendix

In this section you should give a detailed description of what you did (statistically) and how you did it. NOTE: This section is NOT included in the 6 page limit; it can be a separate file submission. Give your formal null and alternative hypotheses here and not in the body of the paper. (Your paper should have your research question and a conclusion which is essentially your alternative hypothesis.) Describe how you used your software or applets to do the analysis, the details of variable creation and any other information about how you conducted the study that may be important that isn't already in the paper. Software output or applet screenshots will make up a significant portion of this section. THIS (Not the body of the report) IS THE SECTION WHERE YOU CANNOT HAVE TOO MUCH DETAIL! Explain and show me why you did what you did. I should be able to recreate your analysis exactly based on I see in this section.

9. Database

You should also upload a copy of your data to Moodle if you have **quantitative** data (Excel or text file). **For categorical data, you just need to give summarized results (two-way table) in your paper and appendix.**

GRADING

Overall, you will be assessed on the areas outlined above listed as "Assessment". Additionally, you will be assessed on the following areas with regards to writing quality:

1. Is the paper well-organized? (Paragraphs organized in a logical manner)
2. Is each paragraph well-written? (Clear topic sentence, single major point)
3. Is the paper generally well-written? (Good use of language, sentence structure)
4. Are tables/figures labeled correctly and referenced accordingly
5. Does the entire paper flow and answer the research question(s) sufficiently? Is there extraneous information presented?

Presentation Guidelines

Your presentation slides should be a very short, bulleted version of your paper. You should have pretty much the same sections:

1. Title and Authors
3. Background and Significance
4. Methods
5. Results
6. Discussion/Conclusions
7. References

Don't gloss over the descriptive statistics and the methods of your data collection. They are an important part of telling the story. **Pictures of your data collection would be nice to see!**

Project Ideas

Your project idea should be one that is academic in nature and one you can find prior research about. It can be a replication of a previous study or something totally original. Most likely it should be one that answers a small part of some bigger question.

I have some links to apps on our stats webpage that you could use in your study. There are some reaction time apps, memorization apps, and a brain test.

- What is associated with brain lateralization? Gender, handiness, math ability, etc.
- Can people memorize objects better if they are shown the objects in pictures or in words?
- Did you just cut me off? See if a person reacts to being cut in line by a specific gender and whether males and females respond differently.
- Do age, gender, major, distraction, etc. affect memory?
- I need to make a call. Find out if male or female students are more likely to lend a phone to a stranger. Does saying "please" help?
- Does listening to different types of music affect a person's reaction time.
- Do Energy Drinks give you energy? Does consumption of an energy drink allow students to complete more sit ups?
- Does what one consider a serving size differ with gender, age, or athlete/non-athlete.
- Can people accurately estimate the length of a short event like a song snippet?
- Size estimates. Do people estimate the amount of a food item differently if they are given a small spoon or a large spoon, a small bowl or a large bowl, etc.?
- Do people like the taste of water better if they think it costs more?
- Does the amount of candy in a bowl effect whether or not people obey the sign that says take only one?
- Do men and women differ on whether or not they tell someone they have some food on their face?
- Is age related to the time needed to complete and the number wrong in a test to investigate the Stroop effect (color and words)?
- What factors are related to people being able to follow directions when given a short quiz?
- Do reaction times differ depending on the time of day? With distraction? Amount of sleep?
- Do reaction times differ depending on whether they use their dominant or non-dominant hand on the computer mouse?
- Does exercising help one's ability to memorize?
- Is there a relationship between the time of day and whether or not someone yawns when yawned at?
- Will watching certain videos affect someone's emotional state?
- Is there an association between gender, handiness, major on whether or not they see the spinning dancer illusion spin clockwise or counterclockwise?
- Can people memorize pictures of objects easier when the pictures are in color versus black and white?
- Do people prefer a name brand cereal over a store brand in a non-blind taste test and then also in a blind taste test?
- Do gamers have a faster reaction time than non-gamers?

- Will offering an incentive increase the likelihood someone will complete a survey?
- Does the room condition light/dark, alone/with others affect how scared someone is when watching a scary video?
- Is yawning contagious?
- Is recall affected by whether or not you take notes on a computer or by hand?

When deciding on a project topic, think of one that is of interest to you and will be something that could contribute to some broader topic.

Bad: *Are the proportion of female customers larger at JPs or LJs (two coffee shops close to campus)?* Would anyone really care about this? Does this add to some broader topic? Would this ever be published in a national journal?
A bit better: *Will regular coffee drinkers complete a puzzle faster than non-coffee drinkers?* This, as you might guess, be loaded with confounding variables.
Perhaps a bit better: *Do gamers have a faster reaction time than non-gamers?* While this one will also have confounding variables, it would seem that gamers should have a better reaction time since that is probably a big part of what they do when playing games. To make this even better you could control for other variables, like a person's sex.
Even better: *Does bowl size affect how much cereal someone will serve themselves?* Now we have a randomized experiment and have the potential to determine cause and effect---this is, of course, assuming it is a nicely controlled randomized experiment.

To Type or To Write:
A Study on the Effects of Different Note-Taking Methods

D. Harman, R. Roberts, M. Ruff

Abstract:
We compare the ability of students to memorize material between those taking notes longhand and those taking notes on a computer. To study these effects, we had a sample of 40 students (20 men and 20 women), who were randomly assigned to either paper based or computer based note taking over a video about the sun. They then were asked to take a quiz covering material from the video. Recorded from each subject were: gender, assigned note-taking method, and quiz results. The first test examined the results of the participants who took either electronic notes or handwritten notes. We found significant evidence that those who take notes longhand, on average, scored higher than those who take notes using a computer. The second test compared the quiz results between men and women which resulted in females scoring slightly higher on the quiz, on average, than men, but not significantly.

Background and Significance:

Taking notes is crucial to the learning and understanding of subject material. The practice is one of the most popular ways students retain information during courses and a key factor in the memorization of material. Longhand, or pen and paper notes, is generally thought to be the traditional note-taking method. Yet in recent years, electronic note taking has become more popular as technology continues to advance and new devices become more mobile. Some schools have even begun to implement programs which require students to use tablets when taking notes (Kim et al. 2016).

However, new research argues the distractions which come along with computer based note taking have hindering effects (Quade 1996). Such problems interfere with the conceptual understanding of information, even when the computer based note-taking method is used correctly (Mueller and Oppenheimer 2014). The same study also mentioned there was no data which suggested significance between note-taking methods and the understanding of factual information. We further expanded the study by first measuring the accuracy of both note-taking methods and then recording the gender of our subjects. The data were collected and then used to determine the effects note-taking methods have on factual memorization.

The research was approached through a two questions, “Does taking notes on paper result in higher performance on memorization quizzes than taking notes on electronic devices?” and “Does performance differ between males and females.”

Methods:

We collected data by asking friends to participate in the study. The sample was not completely random as we knew those who were taking part in the study. For each subject we flipped a coin to assign which method they would use for taking notes. Once the method was

assigned we played a video and had each participant take notes. In order to ensure accurate data we chose to show the participants an astronomy video about the sun, assuming they did not have previous knowledge on the subject. We did not tell them we were going to quiz them at the conclusion of the video, nor did we tell them we why we were running the study. We recorded the assigned note-taking method, the quiz score, and gender of each participant.

The video titled, "The Sun Crash Course Astronomy 10" was produced by PBS Digital Studios and was posted to YouTube on March 19, 2015. By showing each participant the same video we were able to reduce variability in miscommunicated information; each participant was shown the same data and it was presented the same way every time. We began the video at 1:20 and showed it until the end. Participants were only allowed to view the video once and were unable to stop or repeat sections of the video. Other than their assigned method, there were no restrictions or instructions on how to take notes; we simply encouraged them to take notes as they usually would. Participants were allowed to ask questions before the video began to avoid any confusion. Again, by keeping the study consistent and simple we were able to include all trials as data points. Once the video was over we collected notes and gave the quiz. There was no time limit on the quiz and each subject was told to answer every question. Once the quiz was completed we graded them and recorded the data.

Results of Test 1: Examining difference in performance on quiz with different note-taking methods

We first tested to see if taking notes on paper results in higher quiz scores, on average. The mean quiz score for the handwritten group was 6.92 (SD=1.07) and the mean quiz score for the electronic device group was 5.50 (SD=2.04). The observed difference in means (handwritten − electronic device) was 1.425 points, meaning those who took paper based notes in the sample scored, on average, 1.425 points higher than those who took electronic notes in the sample. The results are shown in Figure 1.

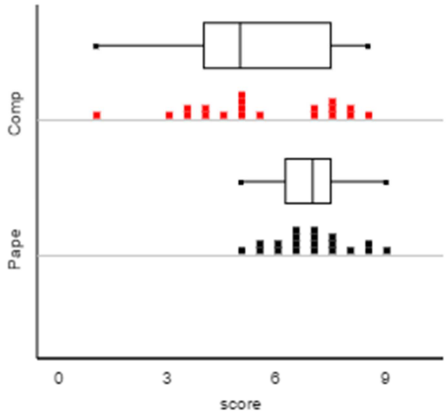


Figure 1: The results of those who took handwritten notes (on bottom in black) compared to those who took notes on the computer (on top in red). Each dot represents the recorded quiz score from the study. The electronic device group has a few outliers that could skew the data. The mean quiz results of the handwritten groups are slightly larger, showing those who took handwritten notes performed better on the quiz.

As seen in Figure 1 there are a few outliers in the electronic device group. Their quiz scores were lower than those who took handwritten notes. Doing a simulation-based test to compare the two means with 10,000 simulations we found a (one-sided) p-value of 0.0042; this p-value is below 0.05 so we have strong evidence against the null hypothesis. The 95% confidence interval for the difference in means is (0.3661, 2.4739), meaning that we are 95% confident that the mean quiz scores of those who took paper-based

notes will be 0.3661 points to 2.4739 points higher than those who took electronic-based notes. The completely positive interval is significant because the observed difference was never zero.

Result of Test 2: Examining difference in performance on quiz between men and women

We then tested to see if there was a difference in quiz scores between males and females. The mean quiz score for the male group was 6.08 (SD=1.43). The mean quiz score for the female group was 6.35 (SD=2.07). The observed difference in means (males − females) was -0.275 points, meaning the males in the sample scored, on average, 0.275 points lower than the females in the sample. The results are shown in Figure 2.

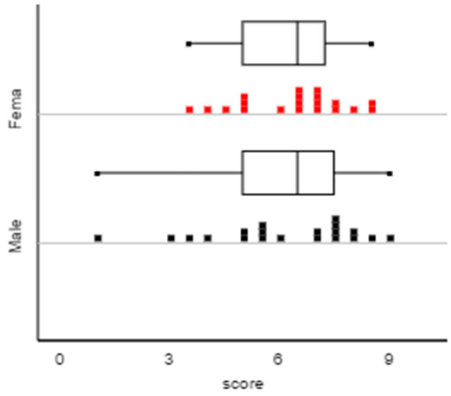


Figure 2: The results of females (on top in red) compared to the males (on bottom in black). Each dot represents the recorded quiz score from the study. The male group has a few outliers that could skew the data. The mean quiz results of the female group is slightly higher, showing that the females did, on average, better than the males on the quiz.

As seen in Figure 2, there are a few outliers in the male group. Their quiz scores were lower than the females. After a 10,000 trial simulation test comparing the two means we found a p-value of 0.5969; this p-value is fairly large so we have very weak evidence against the null hypothesis. The 95% confidence interval for this test is (-1.4136, 0.8736), meaning that we are 95% confident that the mean quiz scores for males will be between 1.4136 points lower than females to 0.8736 higher than females. It is important to note that this confidence interval did contain zero meaning the results were not significant.

Discussion/Conclusion

For the difference in quiz score between longhand vs. computer based note taking, our results lead us to conclude that, on average, college students who take notes longhand will achieve higher scores on fact based quizzes than students who use computer based note-taking methods. We had low p-values and significant results from the 95% confidence interval leading us to conclude we had very strong evidence against the null. These findings actually go against the findings of previous studies, which argue that longhand note-taking skills yield better results on concept-based questions, but not factual-based questions (Mueller 2014). Our test also contains plenty of room for error. Potential variables for this test that were not taken into consideration include: the GPA of subjects, the majors/minors of subjects, the style of note taking (verbatim or idea based), and the setting where the quiz was taken. Moving forward from this, it would be interesting to test the style of note taking vs. fact based quiz score or potential differences that having a higher GPA could have on quiz scores. Students with higher GPA's may be more accustomed to taking more effective notes. Further investigation would help us resolve confounding variables.

The results from our second test lead us to have fairly weak evidence against the null. We had a high p-value and our 95% confidence interval contained zero leading us to our conclusions. Of the 40 individuals tested, 20 were male and 20 were female. Our results were not significant even though in our case the females, on average, scored higher than the males. Like with the earlier test, we did not consider the GPA of subjects, the majors/minors of subjects, the style of note taking (verbatim or idea based), and the setting where the quiz was taken. It would, as with the earlier test, be ideal to substantially increase our sample size and take these potential confounding variables into consideration in order to produce more accurate results.

From the literature we read, we found some of our results to be the same but others to be different, but because of limitations on our end, we must approach conclusions with caution. We did not look carefully into the specifics of each student, as each student learns different and at a different level. We had questions about effective note-taking method with regards to test performance and were able to show, with our conclusions that paper based notes tend to be the best choice for preparing for tests.

References:

Mueller, Pam A. and Oppenheimer, Daniel M. (2014), "The Pen Is Mightier than the Keyboard: Advantages of Longhand Over Laptop Note Taking." Psychological Science (PSS). Sage Journals Database.

Quade, Ann M. (1996), "An Assessment of Retention and Depth of Processing Associated with Notetaking Using Traditional Pencil and Paper and an Online Notepad during Computer-Delivered Instruction." Eric: Institute of Education Sciences.

Kim, H. J., Park, J. H., Yoo, S., & Kim, H. (2016). “Fostering Creativity in Tablet-Based Interactive Classrooms,” Educational Technology & Society, 19 (3), 207–220

Appendix

Video:

"The Sun: Crash Course Astronomy #10"
(https://www.youtube.com/watch?v=b22HKFMIfWo&index=10&list=PL8dPuuaLjXtPAJr1ysd5yGIyiSFuh0mIL)

Quiz:

I used _____ to take notes

A.) Paper
B.) A computer

1.) How many times higher is the pressure of the Sun compared to the pressure of the Earth?

A.) 260
B.) 270
C.) 100
D.) 320

2.) Every second the sun converts _____ tons of Hydrogen into_____tons of helium.

3.) Einstein's famous equation E=MC2 which states that ____ can be converted into ____ and vice versa.

A) Hydrogen, Helium
B) Energy, Mass
C) Light, Heat
D) Helium, Atoms

4.) Where is the convection zone?

A.) 1st Layer
B.) 2nd Layer
C.) 3rd Layer

5.) The Photosphere is:

A) Sphere of Light
B) Where the density of material becomes transparent
C) Where light can shine through
D) All of the above

6..) A solar flare can release as much as _____ of the entire Sun energy output.

A.) 1%
B.) 5%
C.) 10%
D.) 14%

7.) The Corona is Hotter than the Photosphere

A.) True
B.) False

8.) "It is so hot inside the sun that electrons are stripped from their parent atoms creating what is called a _____"

9.) Sunspots can _____ the energy output in the sun.

10.) How much does the sun weigh?_____

Answers:

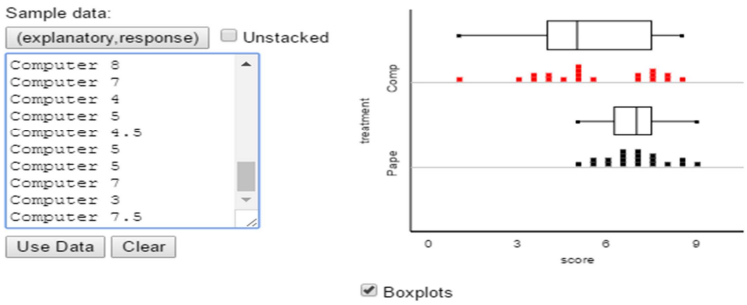
1) A 2) 700 million 695 million
3) B 4) B 5) D 6) C 7) A
8) Plasma 9) Increase 10) 2 octillion kg

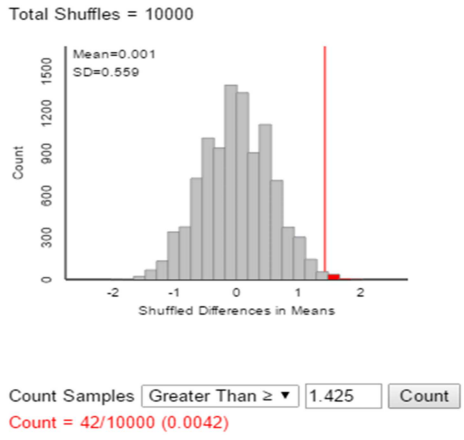
Test 1: Quiz Performance and Note-taking methods

For our first test we had the following hypotheses:

Null: The mean quiz score for those taking notes by hand is the same as the mean quiz score for those taking notes on a computer. ($\mu_p = \mu_c$)
Alternative: The mean quiz score for those taking notes by hand is greater than the mean score for those taking notes on a computer. ($\mu_p > \mu_c$)

We used the applets that go along with the *Introduction to Statistical Investigations* text to do our analysis, http://www.rossmanchance.com/ISIapplets.html. We used the multiple means applet to test the quiz scores of paper-based notes against the quiz scores of computer based notes. We found our observed difference to be 1.425 (Paper minus Computer). Through simulated-based testing, we developed a null distribution of 10,000 trials and found our one-sided p-value to be 0.0042, Using theory-based testing, we found our 95% confidence level of (0.3661, 2.4739).



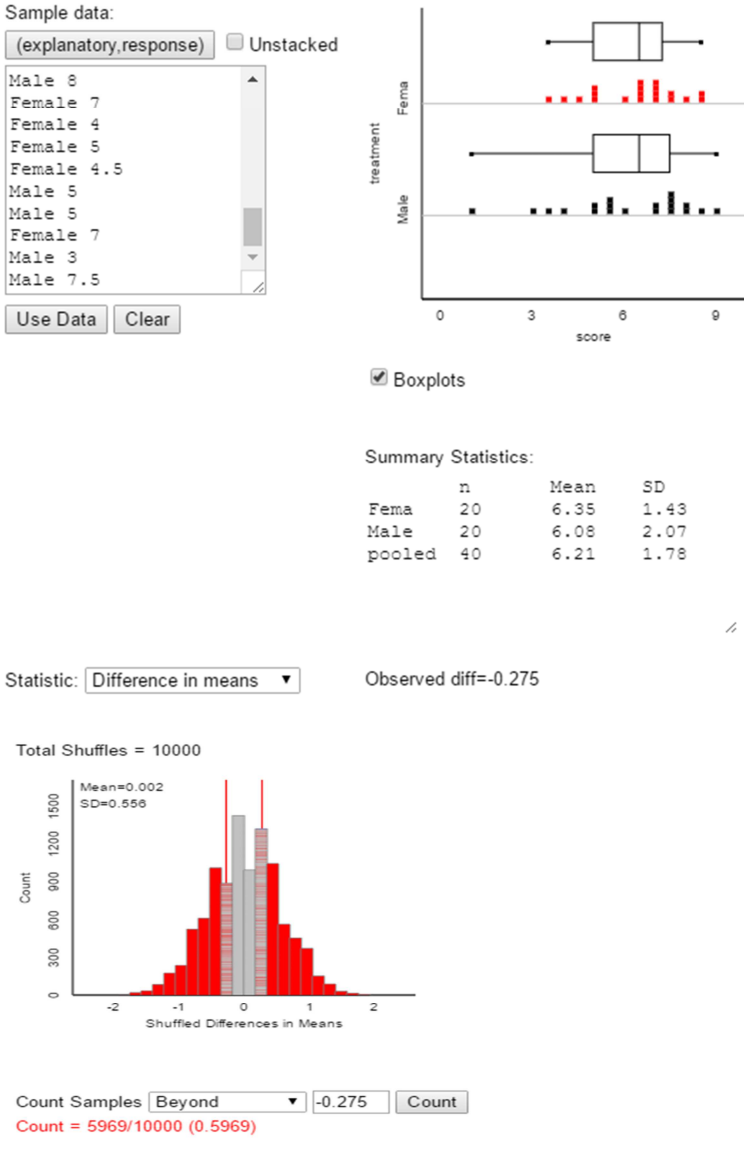


Test 2: Quiz Performance and Gender

For our first test we had the following hypotheses:

Null: The mean quiz score for females is the same as the mean quiz score for males. ($\mu_f = \mu_m$)
Alternative: The mean quiz score for females is different than the mean score for males. ($\mu_f \neq \mu_m$)

We used the multiple means applet again to test the difference in quiz scores between men and women. Our observed difference is -0.275 (males minus females). After a null distribution was created using 10,000 trials, we found our p-value to be 0.5969. We found a theory-based 95% confidence interval of (-1.4136, 0.8736).



Data

Note-taking Method	Score	Gender
Paper	5.5	Male
Paper	5.5	Male
Paper	7	Female
Paper	6.5	Female
Paper	7.5	Female
Paper	5	Female
Paper	8.5	Male
Paper	6	Male
Paper	7.5	Male
Paper	8	Female
Paper	6.5	Female
Paper	7.5	Male
Paper	7	Male
Paper	9	Male
Paper	7	Female
Paper	6	Female
Paper	8.5	Female
Paper	6.5	Female
Paper	7	Male
Paper	6.5	Female
Computer	8	Male
Computer	7.5	Male
Computer	3.5	Female
Computer	3.5	Male
Computer	8.5	Female
Computer	5	Female
Computer	1	Male
Computer	5.5	Male
Computer	4	Male
Computer	7.5	Female
Computer	8	Male
Computer	7	Female
Computer	4	Female
Computer	5	Female
Computer	4.5	Female
Computer	5	Male
Computer	5	Male
Computer	7	Female
Computer	3	Male
Computer	7.5	Male