The STEM CENTER at SHSU

Teaching Enhancement Grants

Final Report

1. Title:
   Active Learning Space: Team-based learning for an upper-level Statistics course

2. PI name: Di Gao
   Job Title: Assistant Professor of Statistics
   SHSU email: dxg085@shsu.edu

3. Budget:
   $1958.98

4. STEM Course targeted in this project:
   Stat 4374 Section 1, Regression Modeling & Analysis.
   Class meets M/W 3:30 pm to 4:45 pm at STEM Center classroom: Farrington 217
   Enrollment in Spring 2022: 10
   Grade distribution: A A A A A B B B B C

5. IRB #: IRB-2022-100
   Status: Approved (survey)

6. Project design:
   Group-working or Team-Based Learning is an active learning approach that has been shown to improve student engagement and learning outcomes. This project aims to encourage the student to implement "group working" during the whole class. Working as a group forces students to participate and can help them discover the concepts-related. Students working on questions or projects together can help them stay focused and solve problems instantly.

   The course delivery method will be redesigned, and the students in Stat 4374 will participate in this project and use the Active Learning Space to form four groups. The groups will work on practice problems together, and rotate presenting to the whole class. Quizzes, homework, and project required group work as well. A survey will be given at the last class, and proper statistical analysis will be done for more inferences.

7. Project implementation:

   The whole class was assigned into four groups: A, B, C, and D, as shown in Figure 1.

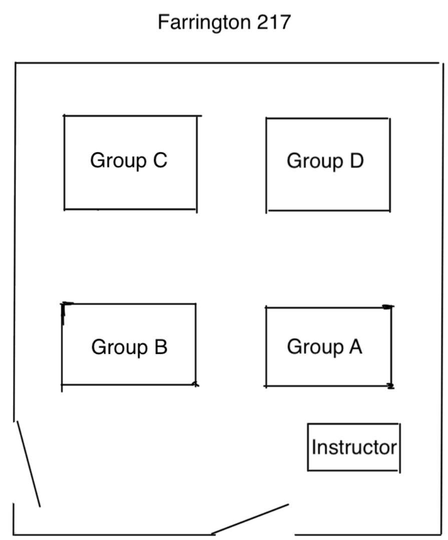


Figure 1. Group Assignment

There are three students in Group A, two students in Group B, three students in Group C, and two students in Group D. All groups are encouraged to have in-class discussions and must finish certain in-class activities and a portion of the quiz problems as a group, especially when computer coding is heavily involved.

Students are encouraged to bring their laptops (one per group) due to the need for computer coding in this regression analysis class. Throughout the semester, there was no issue with the computer; for all the lectures, each group had at least one laptop to work on the problems. The instructor brought one additional laptop as a backup in case a group did not have a computer. Students can also use a tablet (provided by the instructor) to present hand-written solutions. The program R (free) is required, and students need to use R to do their homework, quiz, test, and project.

R is a programming language for statistical computing and graphics supported by the R Core Team and the R Foundation for Statistical Computing. According to user surveys and studies of scholarly literature databases, R is one of the most commonly used programming languages used in data mining. The official R software environment is an open-source, free software environment within the GNU package, available under the GNU General Public License. (wiki)

A typical day of class (the day students had a quiz):

The lecture started at 3:30 pm, and new materials were discussed until 4:00 pm. Students are then prepared to take the quiz. The quiz started from 4:05 to 4:45 pm for 40 mins. For questions 1 to 4, students need to finish these questions individually. Students can either write down the answers on the quiz paper provided or type the answers using R markdown or LaTex. Typically, most students write down the answer, but still, some choose to use technology. For question 5 (the last quiz question), students must answer this question as a team. The quiz is open to all resources; they can discuss and come up with one final answer. Figure 2 is one group's Quiz 3 answer using R Markdown.

5

```
mod<-lm(y~x2+x1, data = data)
anova(mod)
```

```
## Analysis of Variance Table
##
## Response: y
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## x2         1  492.41  492.41  18.113 0.0003523 ***
## x1         1 1564.93 1564.93  57.566 1.905e-07 ***
## Residuals 21  570.88   27.18
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

While our Df, sum Sq and Mean Sq for Residuals stayed the same, the values changed for both x1 ans x2. x2 which become our first variable got a bit smaller while x1 which became our 2nd variable became a bit bigger.

Figure 2. Student quiz answer

Sometimes in the class, the students are asked to give a lecture on a previewed small topic. Each group sent one representative, but the whole group worked as a support, and any group member could jump in at any time. All groups did a good job when given the "mini-lecture," and comments from students indicated they had a good understanding on such a topic. One example is the presentation of explaining the estimated coefficient $\boldsymbol{\beta}$ is unbiased. One group presented the following R code in Figure 3.

Simulation

2022-11-06

```
## Simulation for the unbiased estimator ##
xi<-rnorm(200,60,20)
beta0<-50;beta1<-20
results<-matrix(nrow=10000,ncol=2)
for (i in 1:10000){
  e<-rnorm(200,0,10)
  yi<-beta0+beta1*xi+e
  reg<-lm(yi~xi)
  results[i,]<-coef(reg)
}
head(results) # iterations of estimated beta
```

```
##          [,1]     [,2]
## [1,] 52.12805 19.97304
## [2,] 48.92194 20.02166
## [3,] 51.47167 19.97318
## [4,] 50.90103 19.98540
## [5,] 49.43116 19.99195
## [6,] 47.58017 20.04285
```

```
mean.estimate=colSums(results)/10000
cbind("true beta |"=c(beta0,beta1),"mean of the estimated beta"= mean.estimate)
```

```
##      true beta | mean of the estimated beta
## [1,]          50                   49.98671
## [2,]          20                   20.00017
```

Figure 3. Simulation

Although the instructor provided the R code indicated in the previous Figure, it still took a long time for students to learn, understand, and get ready to present. This group of students scheduled a meeting together after class and ran the code line by line to study. They ended up explaining the materials well and clearly. The process of studying the code together helped them understand more deeply about that chapter's concepts: the $\hat{\beta}$ vector follows a multivariate normal distribution with mean β and variance-covariance matrix $(X'X)^{-1}\sigma^2$. So the expected value of the estimate is the true value of the coefficient. Note that in Figure 3, 49.9867 is very close to the true value of 50.

At the end of the semester (last lecture day), students were asked to participate in a survey regarding this regression class. Survey questions (attached at the end) were approved by IRB and emphasis on active learning. Extra points equivalent to a quiz grade were given to promote students' participation. Students can either click the link provided on Blackboard or use a QR code, as in Figure 4, to start the survey. Students also understood the survey is completed confidential and no trace of who did the survey. In the end, the participation rate was at 100%.

Figure 4. End of the class survey – QR code

Figure 5 is a photo taken on the last class day with students from each group.

Figure 5. Students from each group

8. Results:

8.1: Descriptive results:

a. 100% of students agreed and participated in the survey.
b. The gender distribution is 50% male students and 50% female students.
c. The grade distribution is 50% A, 40% B, 10% C, and 0% for D and lower.
d. 90% of students are majoring in Mathematics, and 10% are majoring in Computer Science.
e. 90% of students are minoring in Statistics, and 10% of students are minoring in Education.
f. 90% of students are seniors, and 10% are juniors.
g. 80% of students agree that they contribute meaningfully to class discussions. See the corresponding Figure below.

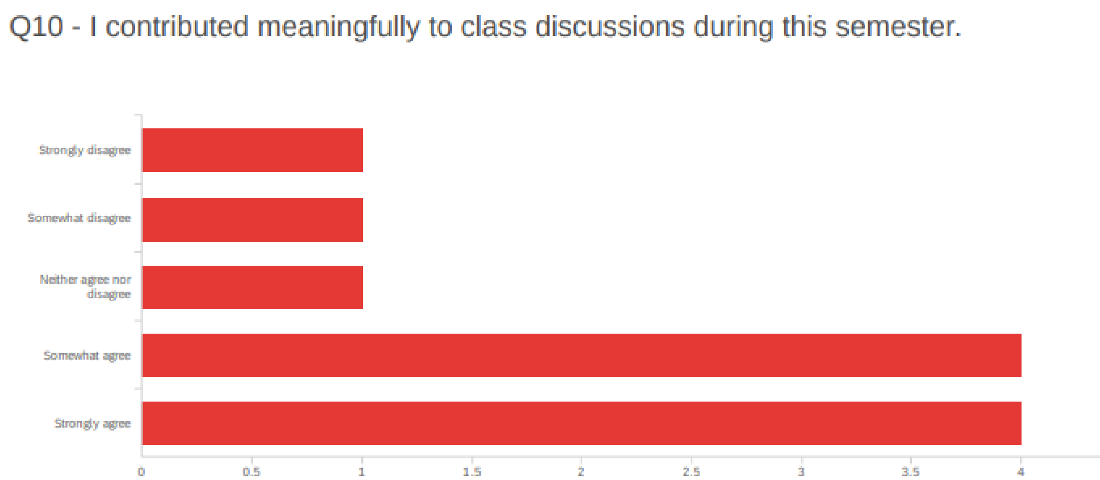


Figure 6. Q10 Result

h. 90% of students agree that they pay attention to the lecture most of the time in class.

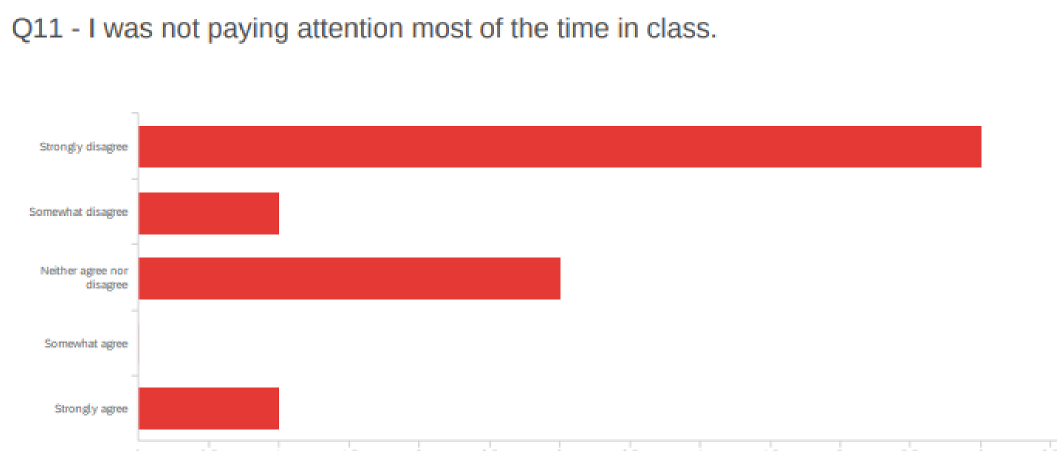


Figure 7. Q11 Result

i. 90% of students think they are active learners for this class period.

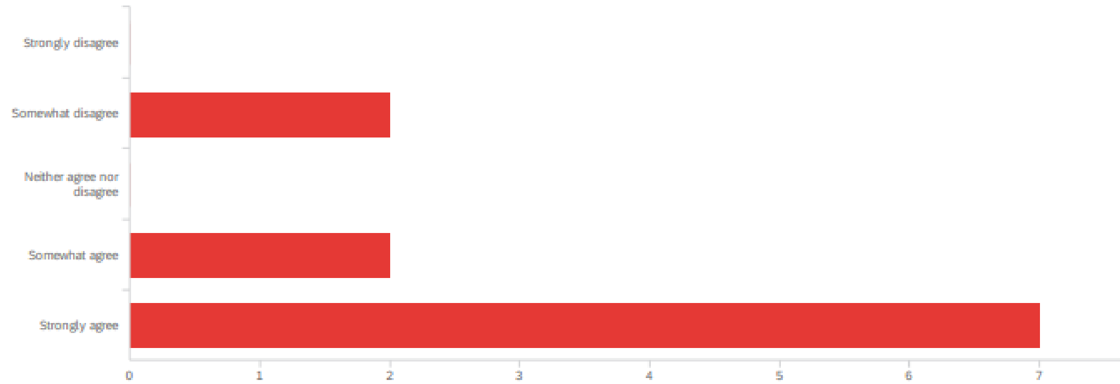


Figure 8. Q11 Result

j. 80% of students think the whole class is actively involved.

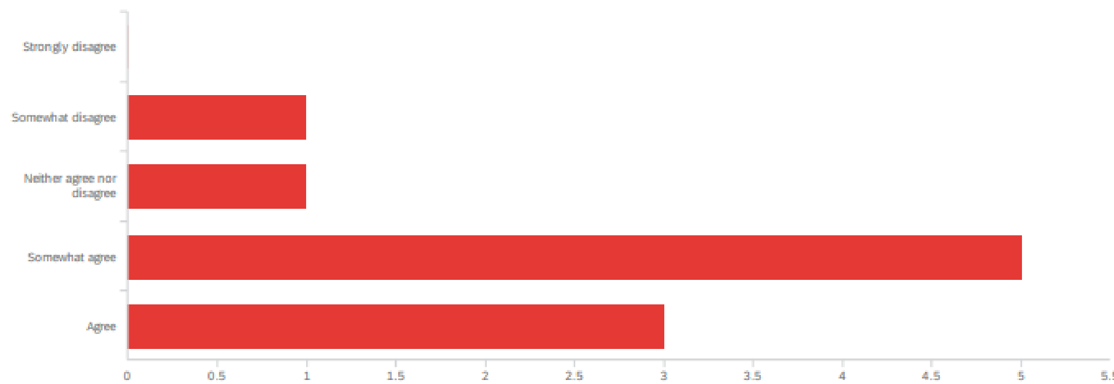


Figure 9. Q12 Result

k. 90% of students are confident about solving real-world questions on the topic of regression.

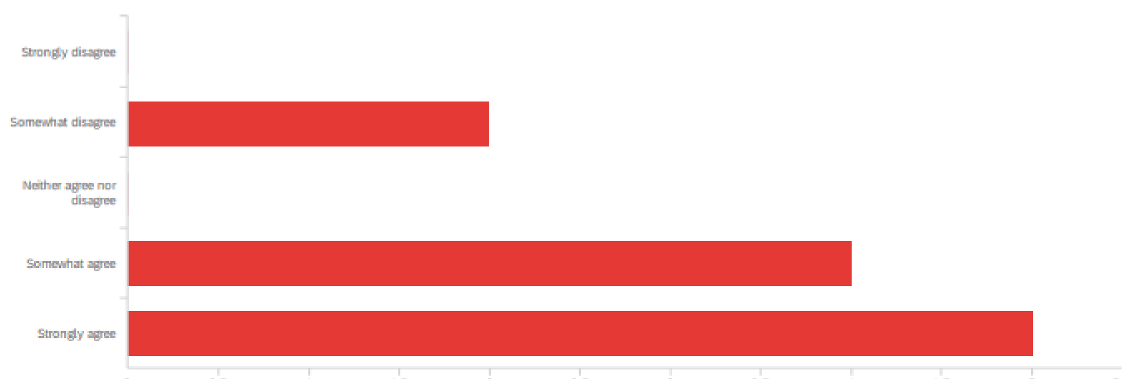


Figure 10. Q17 Result

l. 80% of students feel confident consulting others on regression analysis.

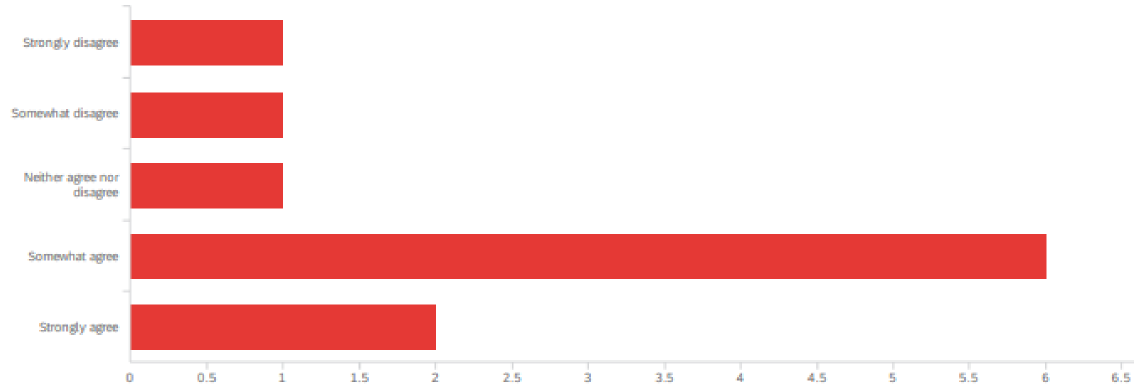


Figure 11. Q19 Result

m. 90% of students think this class help in improving their presentation ability.

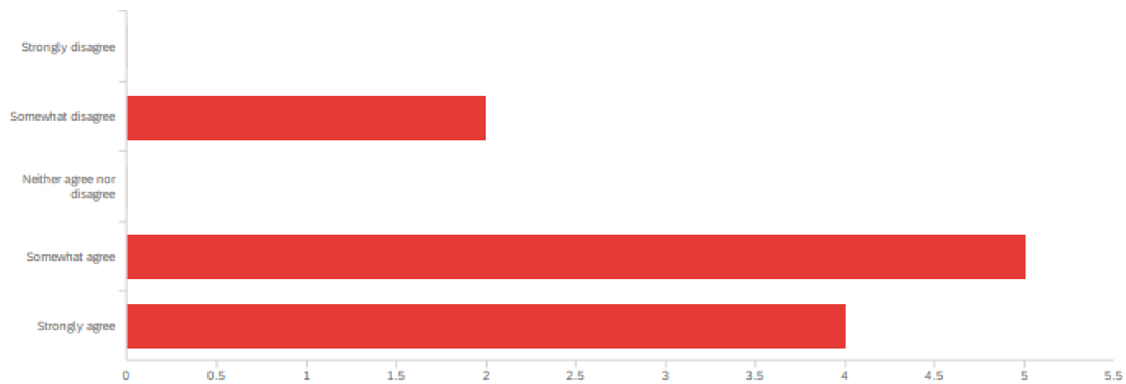


Figure 12. Q20 Result

n. 90% of students would like to recommend this class to other students.

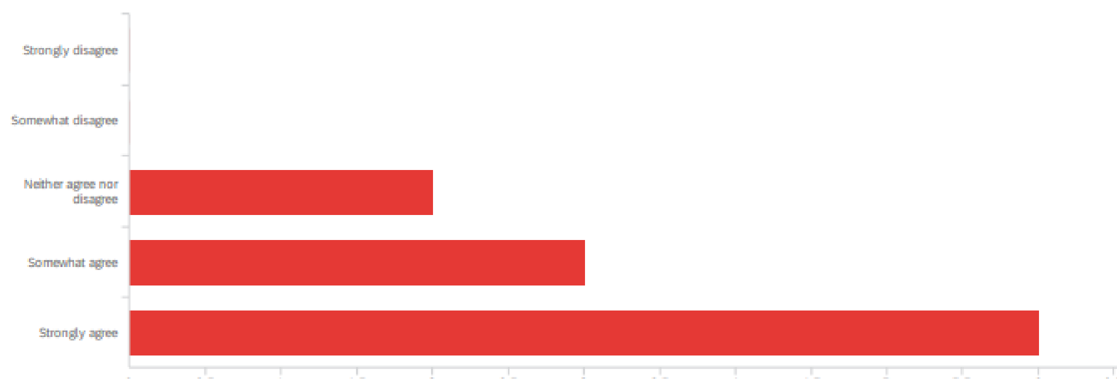


Figure 13. Q23 Result

o. 90% of students feel engaged in this class.

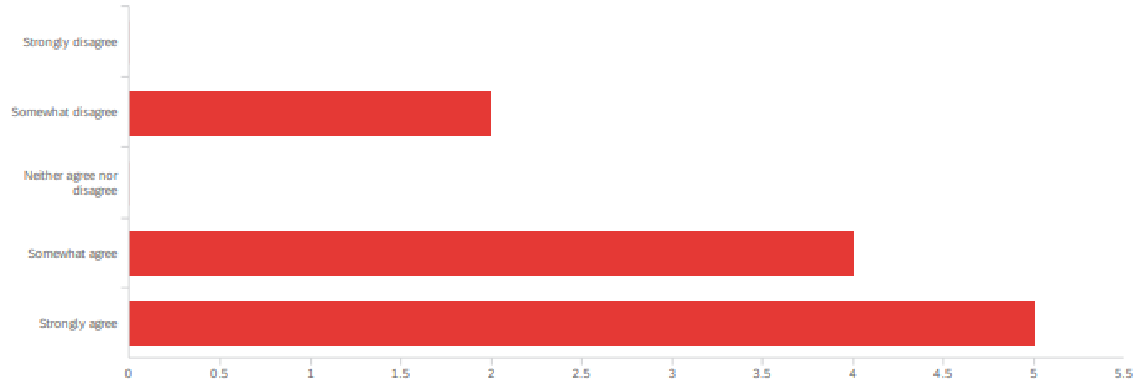


Figure 14. Q24 Result

p. 80% of students think this class improves their ability to work as a team.

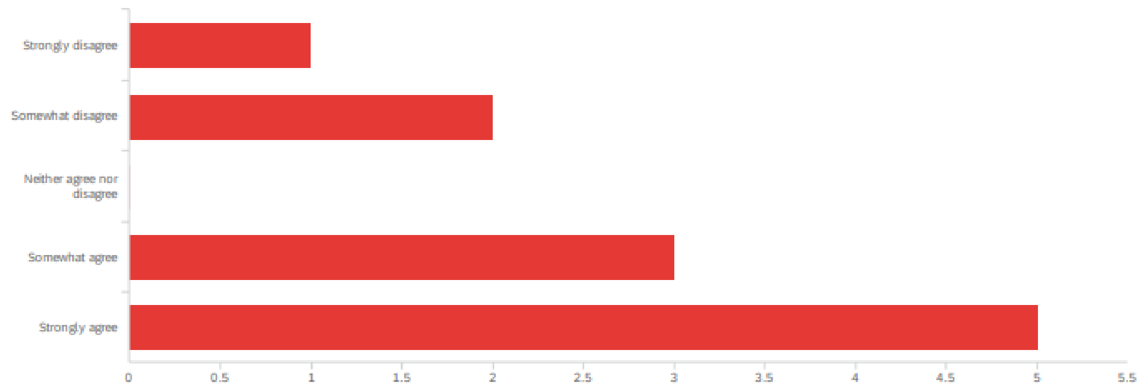


Figure 15. Q25 Result

q. 70% of students think the set-up of this class helps in learning the materials.

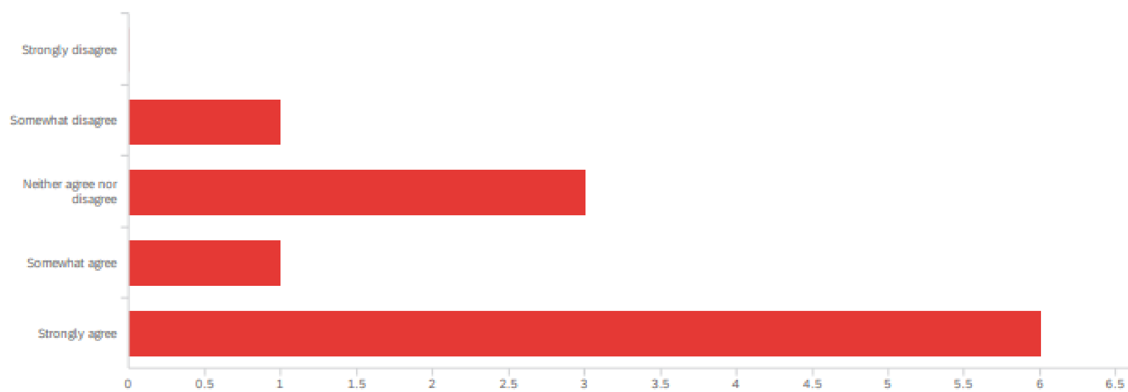


Figure 16. Q27 Result

8.2: Inferential results:

Here we use the final weighted grade as the response. Since STAT 4374 only offered one section in Spring 2022, we used the graduate regression class as a control group. We first test the grade differences using one-way ANOVA without adjusting the level of students.

The response is listed in the table below:

Treatment:	90.98	91.01	87.72	81.47	86.57	85.61	91.45	89.43	70.28	88.86
Control:	90.33	85.75	89.83	92.05	74.62	85.43	92.48	91.33		

Since both groups' sample sizes are different, we implemented the unbalanced design.

We first run the following R code to import the data:

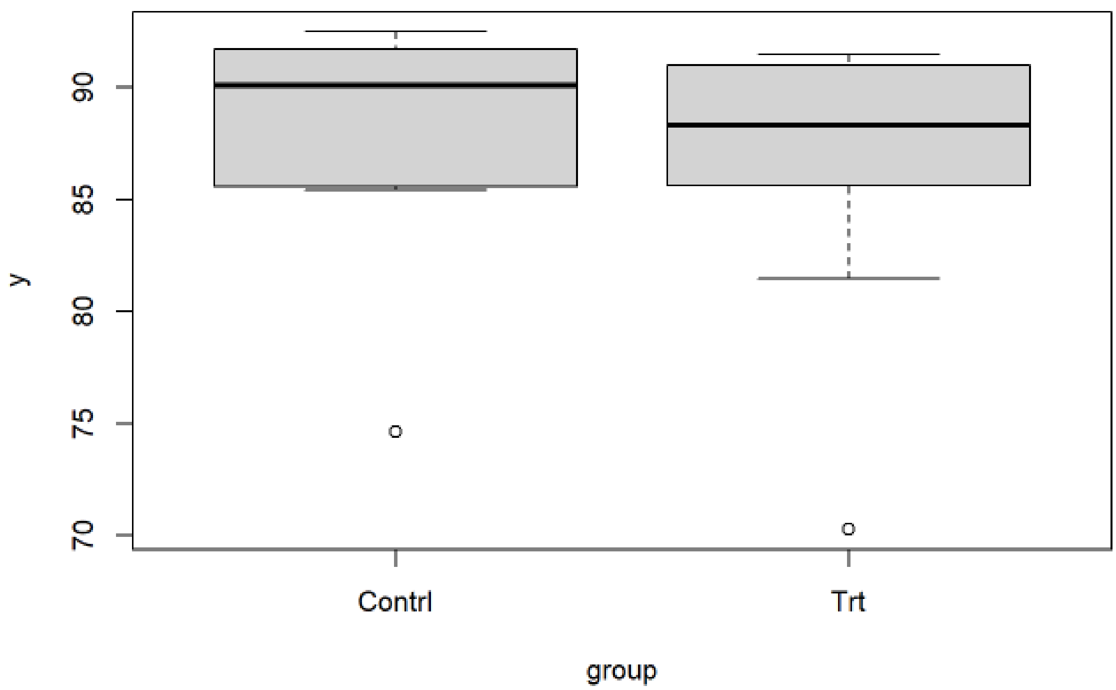
```
trt = c(90.98,91.01,87.72,81.47,86.57,85.61,91.45,89.43,70.28,88.86)

contr = c(90.33,85.75,89.83,92.05,74.62,85.43,92.48,91.33)

y = c(trt,contr)

group = c(rep("Trt",length(trt)),rep("Contrl",length(contr)))

data = cbind.data.frame(y,group)

data
```

```
##        y  group
## 1  90.98    Trt
## 2  91.01    Trt
## 3  87.72    Trt
## 4  81.47    Trt
## 5  86.57    Trt
## 6  85.61    Trt
## 7  91.45    Trt
## 8  89.43    Trt
## 9  70.28    Trt
## 10 88.86    Trt
## 11 90.33 Contrl
## 12 85.75 Contrl
## 13 89.83 Contrl
## 14 92.05 Contrl
## 15 74.62 Contrl
## 16 85.43 Contrl
## 17 92.48 Contrl
## 18 91.33 Contrl
```

Figure 17. Data

Then we present the boxplot and perform an equal variance check.

```
boxplot(y~group)
```




```
bartlett.test(y~group)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  y by group
## Bartlett's K-squared = 0.043384, df = 1, p-value = 0.835
```

Figure 18. Assumption checking

From the Bartlett test, p-value = 0.835, we then fail to reject the null hypothesis of equal variance. The assumption holds here.

We can then run the ANOVA test. In addition, a non-parametric test is also considered here.

```
test = aov(y~group,data=data)

summary(test)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## group        1    8.6    8.58   0.223  0.643
## Residuals   16  615.9   38.49
```

```
kruskal.test(y~group)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  y by group
## Kruskal-Wallis chi-squared = 0.63947, df = 1, p-value = 0.4239
```

Figure 19. ANOVA

P-values from both tests are greater than 0.05, indicating there is no significant difference between the treatment group and the control group. However, the control group is all graduate students, and we should apply some adjustments here. So we now import the adjusted data, using +5% as the adjustment between the treatment and the control group.

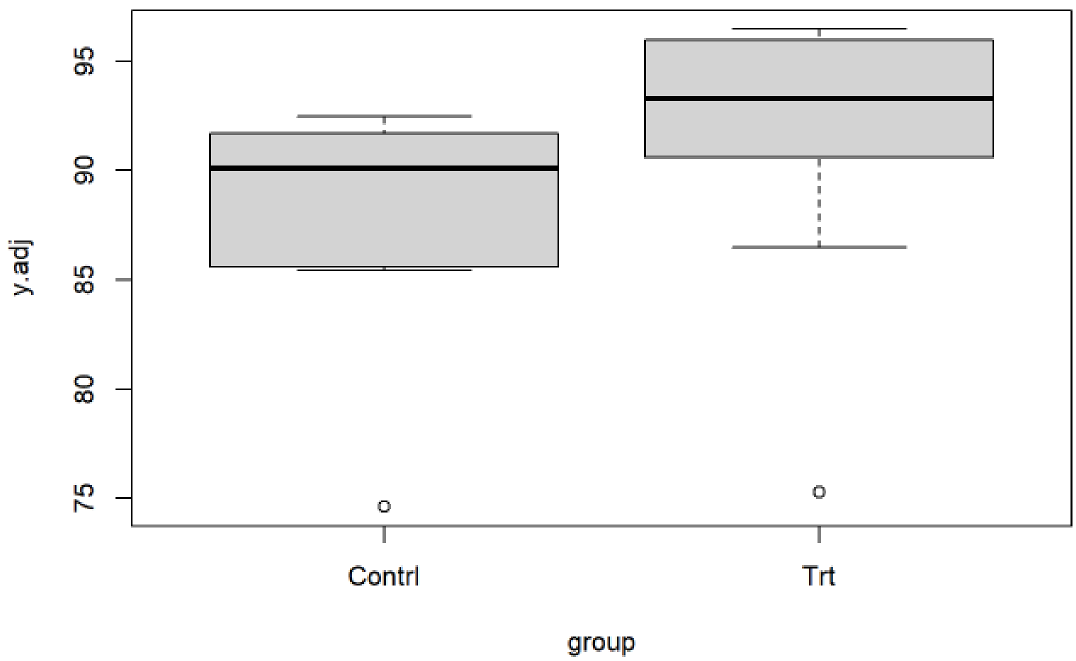
```
trt.adj = trt + 5

y.adj = c(trt.adj, contr)

data.adj = cbind.data.frame(y.adj,group)

data.adj
```

```
##    y.adj  group
## 1  95.98    Trt
## 2  96.01    Trt
## 3  92.72    Trt
## 4  86.47    Trt
## 5  91.57    Trt
## 6  90.61    Trt
## 7  96.45    Trt
## 8  94.43    Trt
## 9  75.28    Trt
## 10 93.86    Trt
## 11 90.33 Contrl
## 12 85.75 Contrl
## 13 89.83 Contrl
## 14 92.05 Contrl
## 15 74.62 Contrl
## 16 85.43 Contrl
## 17 92.48 Contrl
## 18 91.33 Contrl
```

Figure 20. Adjusted data

We check the boxplot and perform the test.

```
boxplot(y.adj~group)
```




```
bartlett.test(y.adj~group)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  y.adj by group
## Bartlett's K-squared = 0.043384, df = 1, p-value = 0.835
```

```
kruskal.test(y.adj~group)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  y.adj by group
## Kruskal-Wallis chi-squared = 4.1763, df = 1, p-value = 0.04099
```

Figure 21. Adjusted Test Result

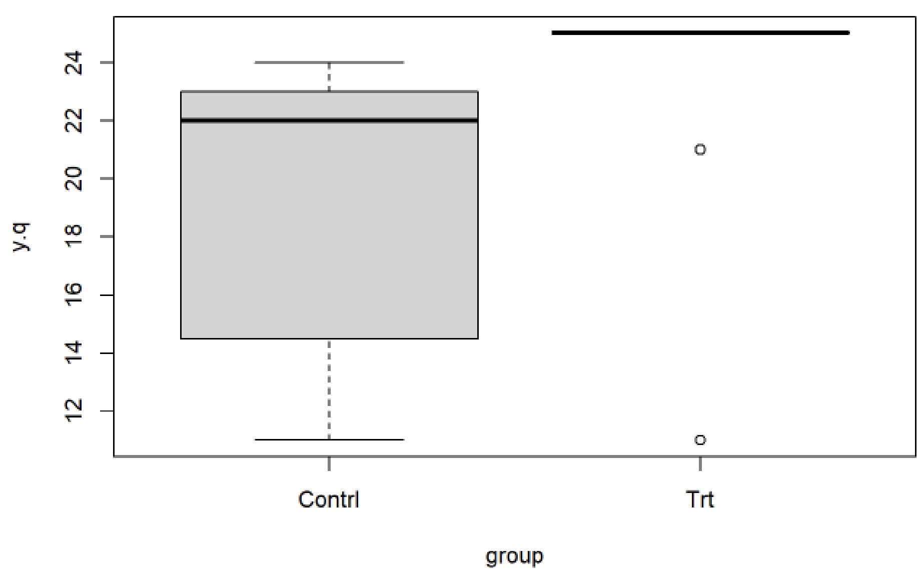
The adjusted test result returns a p-value = 0.041, which is smaller than 0.05; we now conclude a significant difference between the control group and the treatment group.

We can also compare one of the Quiz grades. No active learning technique was performed in the control group (graduate students), and in the treatment group, an active learning structure was implemented. The quiz data are as follows:

Treatment:	25	25	25	25	21	25	25	25	11	25
Control:	23	16	22	24	11	13	22	23		

The test result is shown below in Figure 22.

```
q.trt = c(25,25,25,25,21,25,25,25,11,25)

q.ctl = c(23,16,22,24,11,13,22,23)

y.q = c(q.trt, q.ctl)

data.q = cbind.data.frame(y.q, group)

boxplot(y.q~group)
```




```
kruskal.test(y.q~group)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  y.q by group
## Kruskal-Wallis chi-squared = 6.5593, df = 1, p-value = 0.01043
```

Figure 22. Quiz Result

We can see, again, the p-value = 0.0104, which is smaller than 0.05. Hence, there is a significant difference between the group using an active learning structure and the group using no active learning techniques.

More statistical analysis can be performed based on the current data obtained. Other than that, a different way of experimental design can be implemented. In the future study of this project, one can randomly sample grade sections between the treatment and the control group.

9. Conclusion.

In conclusion, although we are working on a one-semester-only project with a relatively small sample size, we can still see a positive response in the active learning structure. Overall, through this project on undergraduate regression analysis, students got a good understanding of the concepts and improved in classroom engagement. A follow-up project could implement to reduce the noise of the statistical analysis in this report.

Appendix I. IRB Approval

IRB #: IRB-2022-100
Title: Active Learning Space: Team-based learning for an upper-level Statistics course
Creation Date: 4-18-2022
End Date:
Status: Approved
Principal Investigator: Di Gao
Review Board: SHSU IRB
Sponsor:

Study History

Submission Type Initial	Review Type Exempt	Decision Exempt

Key Study Contacts

Member Di Gao	Role Principal Investigator	Contact dxg085@shsu.edu
Member Di Gao	Role Primary Contact	Contact dxg085@shsu.edu

Appendix II. Survey Questionnaire

Start of Block: Default Question Block

Q1 Hello, I am Dr. Di Gao from the Department of Mathematics and Statistics at Sam Houston State University. I am conducting a survey assessing students' performance and satisfaction of the Active Learning class - regression analysis. Your participation in this survey will be greatly appreciated as the goal is to improve student learning outcomes in the class. The results of the survey will be reported in conference presentations and journal publications.

You will be asked to describe your activities and satisfaction in the class and your demographic characteristics, including your age, employment status, major, minor, and classification. It will take less than 10 minutes to complete the survey.

To qualify for this study, you must be 18 years of age or older. Since this is an anonymous study, I will not know who participates. Your decision to participate or not will in no way impact your class grade.

Your survey responses will be kept confidential to the extent of the technology being used. Qualtrics collects IP addresses for respondents to surveys they host; however, the ability to connect your survey responses to your IP address has been disabled for this survey. That means that I will not be able to identify your responses. You should, however, keep in mind that answers to specific questions may make you more easily identifiable. The security and privacy policy for Qualtrics can be viewed at https://www.qualtrics.com/security-statement/.

If you have any questions regarding this survey, please contact Dr. Gao at 936-294-3523. If you have any questions regarding your rights as a human subject and participant in this study, or to report research-related problems, you may call Sharla Miles, administrator for the Institutional Review Board at SHSU for information, at (936) 294-4875, or irb@shsu.edu.

○ I Agree (1)

○ I Do Not Agree (2)

Skip To: End of Survey If Q1 = I Do Not Agree

Q2 What is your age? Please enter a numerical number only. For example, 20.

____

Q3 What is your gender?

- ○ Male (1)
- ○ Female (2)

Q4 What is your major?

____

Q5 What is your minor?

____

Q6 What is your classification?

- ○ Freshman (1)
- ○ Sophomore (2)
- ○ Junior (3)
- ○ Senior (4)
- ○ Graduate (5)

Q7 What is your current overall GPA?

- < 2.0 (1)
- 2.0 < GPA ≤ 2.5 (2)
- 2.5 < GPA ≤ 3.0 (3)
- 3.0 < GPA ≤ 3.5 (4)
- 3.5 < GPA ≤ 4.0 (5)

Q8 Describe your employment status.

- Not working (1)
- Employed < 20 hrs/wk (2)
- 20 hrs/wk < employed ≤ 30 hrs/wk (3)
- 30 hrs/wk < employed ≤ 35 hrs/wk (4)
- 35 hrs/wk < employed ≤ 40 hrs/wk (5)

Q9 Is this course required for your degree plan?

- Just elective, not required by major or minor (1)
- required by major (2)
- required by minor (3)

Page Break

Q10 I contributed meaningfully to class discussions during this period.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q11 I was not paying attention most of the time in class.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q12 I contributed my fair share to class discussions.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q13 I participated in class discussions during this semester.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Page Break

Q14 I talked in class with other students about class material.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q15 I was mostly a passive learner for this class during this period.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q16 I paid attention most of the time in class.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q17 I was mostly an active learner for this class during this period.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q18 Most students were actively involved in class during this period.

- Strongly disagree (30)
- Somewhat disagree (31)
- Neither agree nor disagree (32)
- Somewhat agree (34)
- Agree (35)
- N/A (68)

Q20 I am confident about the real-world application on the topic of Regression Analysis.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q22 I am confident about the real-world application of general statistics.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q23 I feel confident to explain regression analysis to others.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q24 This class helps me improve the oral presentation ability.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q25 This class helps me improve problems-solving skills.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q26 I am able to connect the lecture concepts to their usage.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

Q27 I would like to recommend this class to other students.

- Strongly disagree (1)
- Somewhat disagree (2)
- Neither agree nor disagree (3)
- Somewhat agree (4)
- Strongly agree (5)

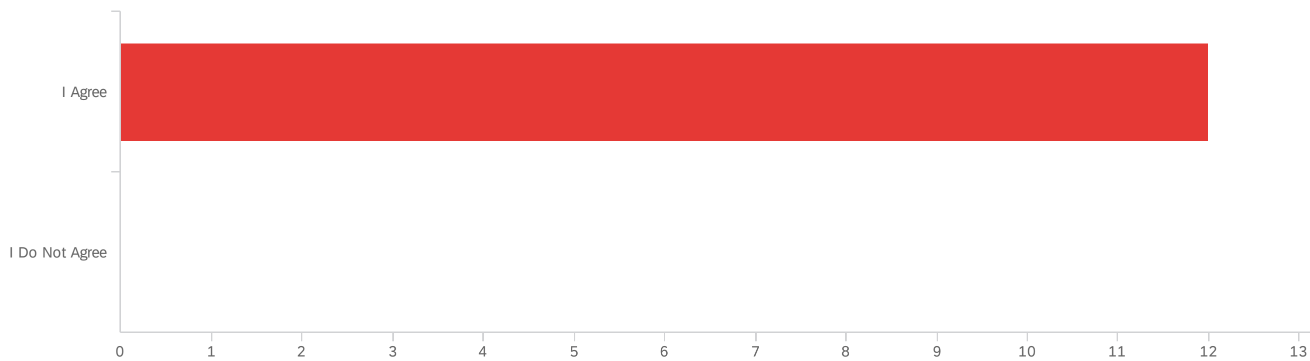
Q28 I feel engaged/ involved during this period of study.

- Strongly disagree (6)
- Somewhat disagree (7)
- Neither agree nor disagree (8)
- Somewhat agree (9)
- Strongly agree (10)

End of Block: Default Question Block

Appendix III. Survey Results

Q1 - Hello, I am Dr. Di Gao from the Department of Mathematics and Statistics at Sam Houston State University. I am conducting a survey assessing students' performance and satisfaction of the Active Learning class - Regression Analysis. Your participation in this survey will be greatly appreciated as the goal is to improve student learning outcomes in the class. The results of the survey will be reported in conference presentations and journal publications. You will be asked to describe your activities and satisfaction in the class and your demographic characteristics, including your age, employment status, major, minor, and classification. It will take less than 10 minutes to complete the survey. To qualify for this study, you must be 18 years of age or older. Since this is an anonymous study, I will not know who participates. Your decision to participate or not will in no way impact your class grade. Your survey responses will be kept confidential to the extent of the technology being used. Qualtrics collects IP addresses for respondents to surveys they host; however, the ability to connect your survey responses to your IP address has been disabled for this survey. That means that I will not be able to identify your responses. You should, however, keep in mind that answers to specific questions may make you more easily identifiable. The security and privacy policy for Qualtrics can be viewed at https://www.qualtrics.com/security-statement/. If you have any questions regarding this survey, please contact Dr. Gao at 936-294-3523. If you have any questions regarding your rights as a human subject and participant in this study, or to report research-related problems, you may call Sharla Miles, administrator for the Institutional Review Board at SHSU for information, at (936) 294-4875, or irb@shsu.edu.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Hello, I am Dr. Di Gao from the Department of Mathematics and Statistics at Sam Houston State University. I am conducting a survey assessing students' performance and satisfaction of the Active Learning class - Regression Analysis. Your participation in this survey will be greatly appreciated as the goal is to improve student learning outcomes in the class. The results of the survey will be reported in conference presentations and journal publications. You will be asked to describe your activities and satisfaction in the class and your demographic characteristics, including your age, employment status, major, minor, and classification. It will take less than 10 minutes to complete the survey. To qualify for this study, you must be 18 years of age or older. Since this is an anonymous study, I will not know who participates. Your decision to participate or not will in no way impact your class grade. Your survey responses will be kept confidential to the extent of the technology being used. Qualtrics collects IP addresses for respondents to surveys they host; however, the ability to connect your survey responses to your IP address has been disabled for this survey. That means that I will not be able to identify your responses. You should, however, keep in mind that answers to specific questions may make you more easily identifiable. The security and privacy policy for Qualtrics can be viewed at https://www.qualtrics.com/security-statement/. If you have any questions regarding this survey, please contact Dr. Gao at 936-294-3523. If you have any questions regarding your rights as a human subject and participant in this study, or to report research-related problems, you may call Sharla Miles, administrator for the Institutional Review Board at SHSU for information, at (936) 294-4875, or irb@shsu.edu.	1.00	1.00	1.00	0.00	0.00	12

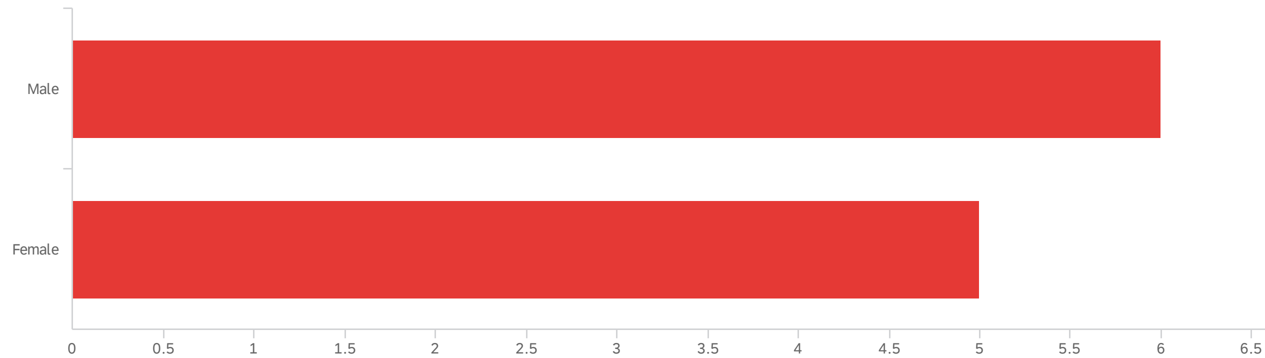
#	Field	Choice Count	
1	I Agree	100.00%	12
2	I Do Not Agree	0.00%	0
			12

Showing rows 1 - 3 of 3

Q2 - What is your age? Please enter a numerical number only. For example, 20.

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	What is your age? Please enter a numerical number only. For example, 20.	20.00	29.00	23.82	2.37	5.60	11

Q3 - What is your gender?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	What is your gender?	1.00	2.00	1.45	0.50	0.25	11

#	Field		Choice Count
1	Male	54.55%	6
2	Female	45.45%	5
			11

Showing rows 1 - 3 of 3

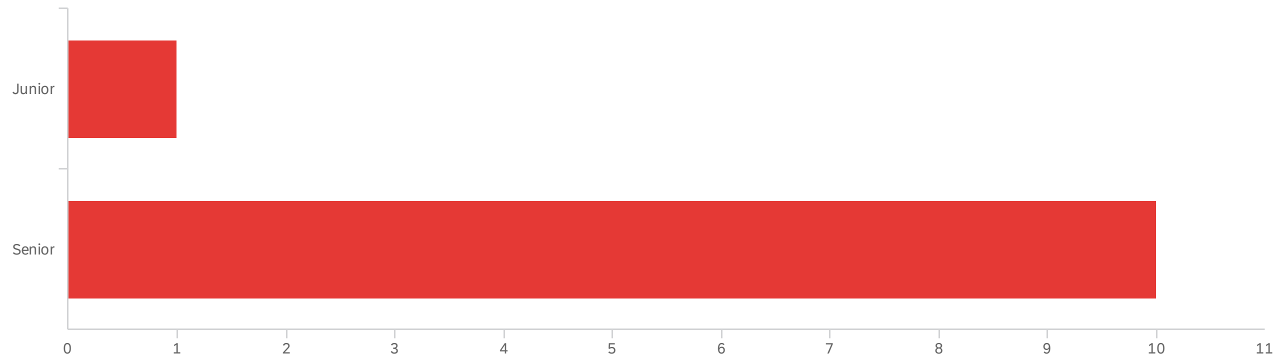
Q4 - What is your major?

What is your major?
Mathematics
Mathematics
Math
Mathematics
Computing Science
Mathematics
Mathematics
Mathematics
Math
Mathematics
Mathematics

Q5 - What is your minor?

What is your minor?
Statistics
Statistics
Stats
Statistics
Statistics
Statistics
Statistics
Secondary Education
Stats
Statistical Theory
Statistical Theory

Q6 - What is your classification?

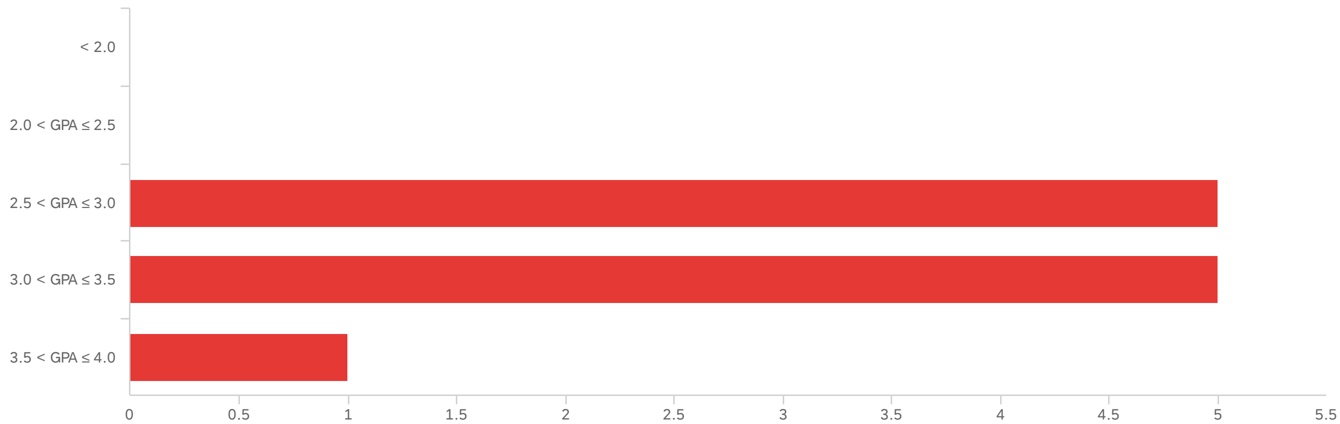


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	What is your classification?	3.00	4.00	3.91	0.29	0.08	11

#	Field		Choice Count
3	Junior	9.09%	1
4	Senior	90.91%	10
			11

Showing rows 1 - 3 of 3

Q7 - What is your current overall GPA?

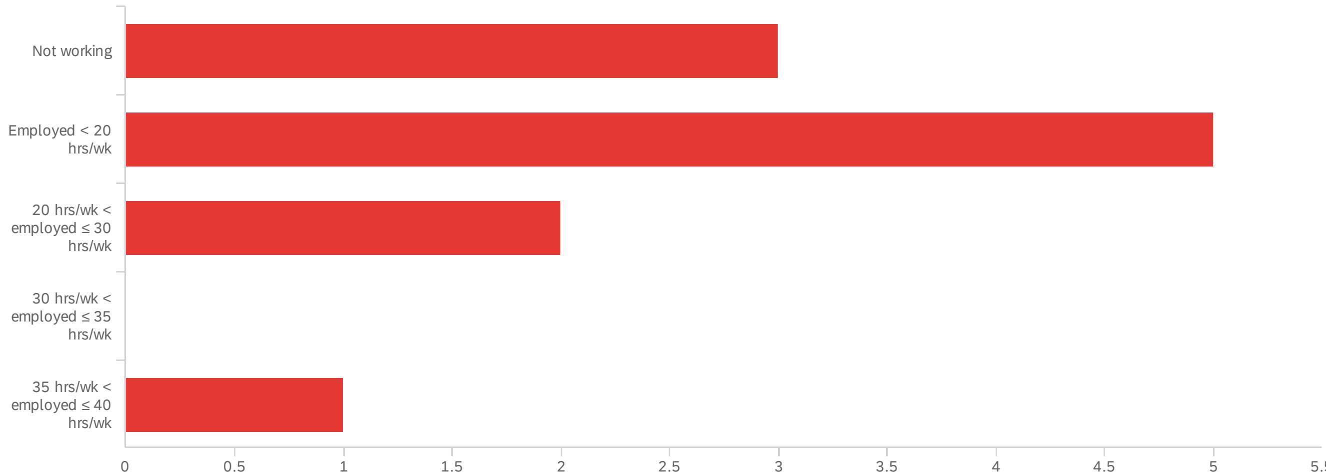


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	What is your current overall GPA?	3.00	5.00	3.64	0.64	0.41	11

#	Field	Choice Count	
1	< 2.0	0.00%	0
2	2.0 < GPA ≤ 2.5	0.00%	0
3	2.5 < GPA ≤ 3.0	45.45%	5
4	3.0 < GPA ≤ 3.5	45.45%	5
5	3.5 < GPA ≤ 4.0	9.09%	1
			11

Showing rows 1 - 6 of 6

Q8 - Describe your employment status.

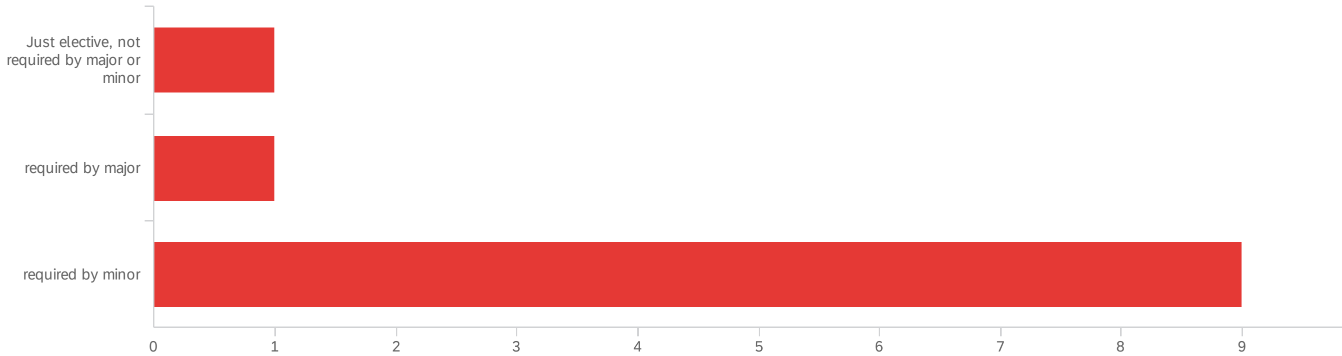


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Describe your employment status.	1.00	5.00	2.18	1.11	1.24	11

#	Field	Choice Count	
1	Not working	27.27%	3
2	Employed < 20 hrs/wk	45.45%	5
3	20 hrs/wk < employed ≤ 30 hrs/wk	18.18%	2
4	30 hrs/wk < employed ≤ 35 hrs/wk	0.00%	0
5	35 hrs/wk < employed ≤ 40 hrs/wk	9.09%	1
			11

Showing rows 1 - 6 of 6

Q9 - Is this course required for your degree plan?

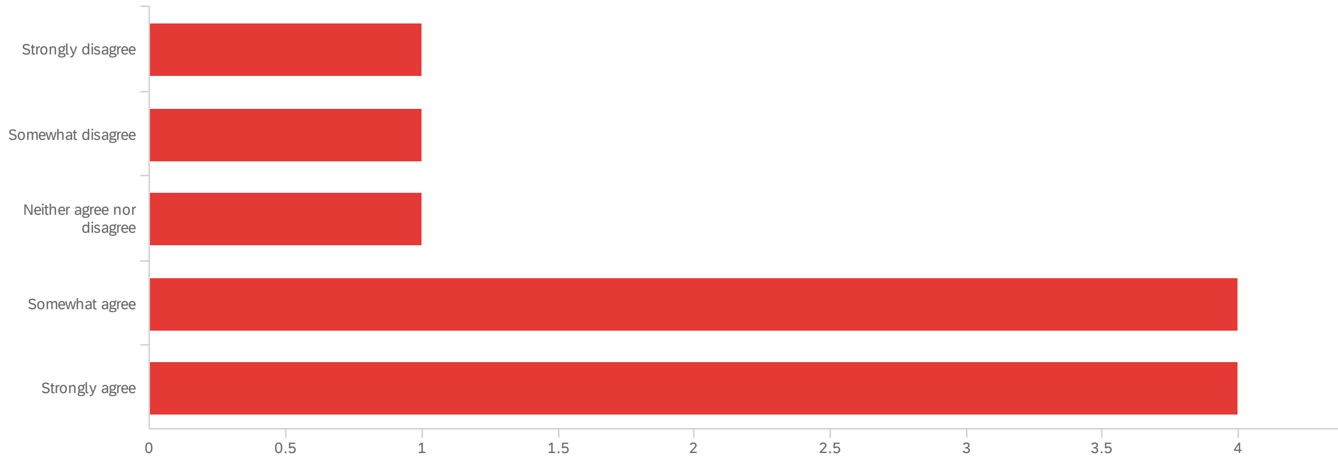


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Is this course required for your degree plan?	1.00	3.00	2.73	0.62	0.38	11

#	Field	Choice Count	
1	Just elective, not required by major or minor	9.09%	1
2	required by major	9.09%	1
3	required by minor	81.82%	9
			11

Showing rows 1 - 4 of 4

Q10 - I contributed meaningfully to class discussions during this semester.

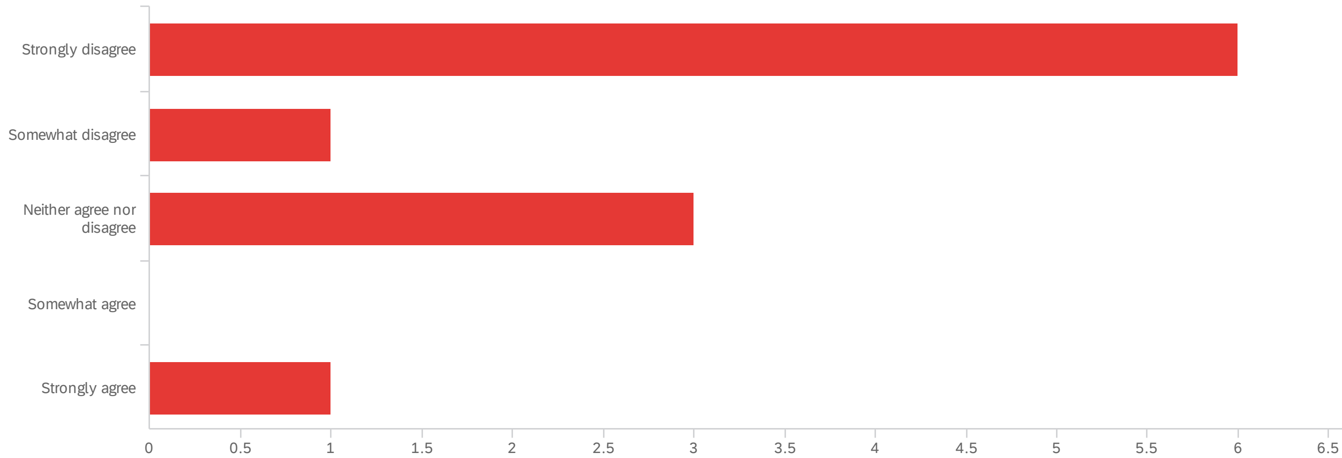


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I contributed meaningfully to class discussions during this semester.	1.00	5.00	3.82	1.27	1.60	11

#	Field	Choice Count	
1	Strongly disagree	9.09%	1
2	Somewhat disagree	9.09%	1
3	Neither agree nor disagree	9.09%	1
4	Somewhat agree	36.36%	4
5	Strongly agree	36.36%	4
			11

Showing rows 1 - 6 of 6

Q11 - I was not paying attention most of the time in class.

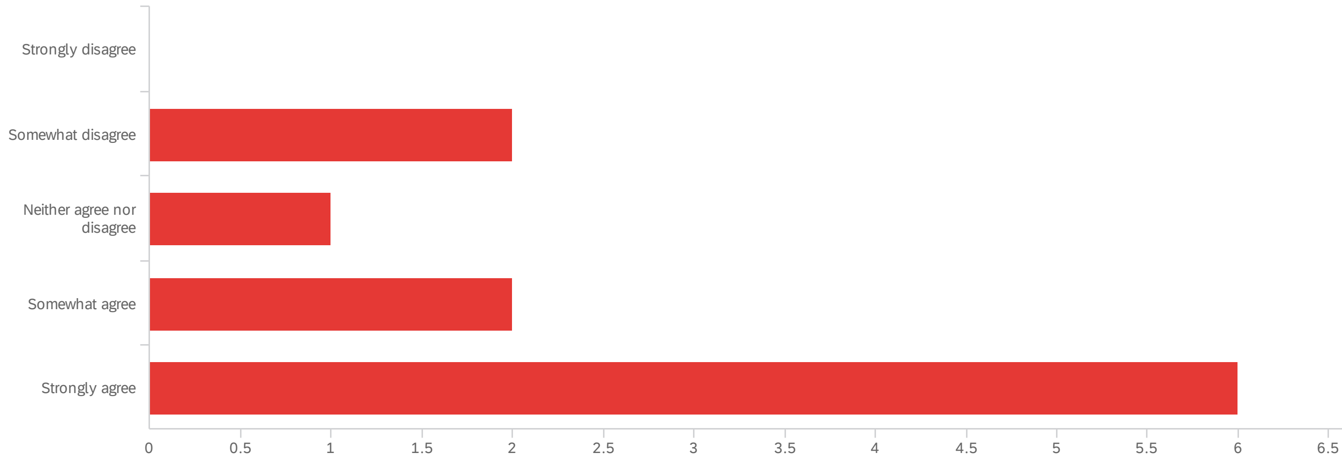


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I was not paying attention most of the time in class.	1.00	5.00	2.00	1.28	1.64	11

#	Field	Choice Count	
1	Strongly disagree	54.55%	6
2	Somewhat disagree	9.09%	1
3	Neither agree nor disagree	27.27%	3
4	Somewhat agree	0.00%	0
5	Strongly agree	9.09%	1
			11

Showing rows 1 - 6 of 6

Q12 - I talked in class with other students about class materials.

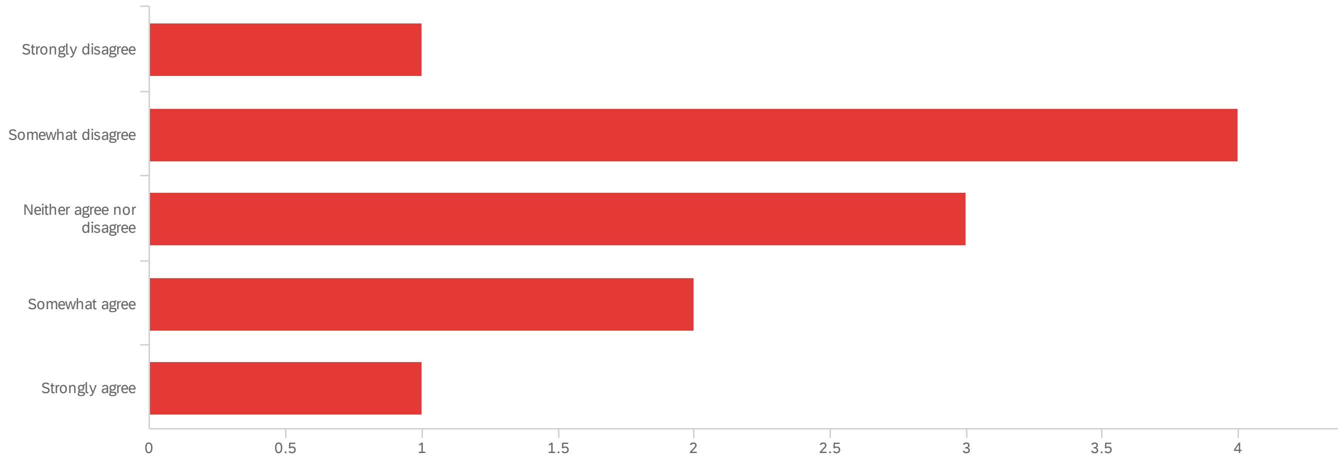


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I talked in class with other students about class materials.	2.00	5.00	4.09	1.16	1.36	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	9.09%	1
4	Somewhat agree	18.18%	2
5	Strongly agree	54.55%	6
			11

Showing rows 1 - 6 of 6

Q13 - I was mostly a passive learner for this class during this semester.

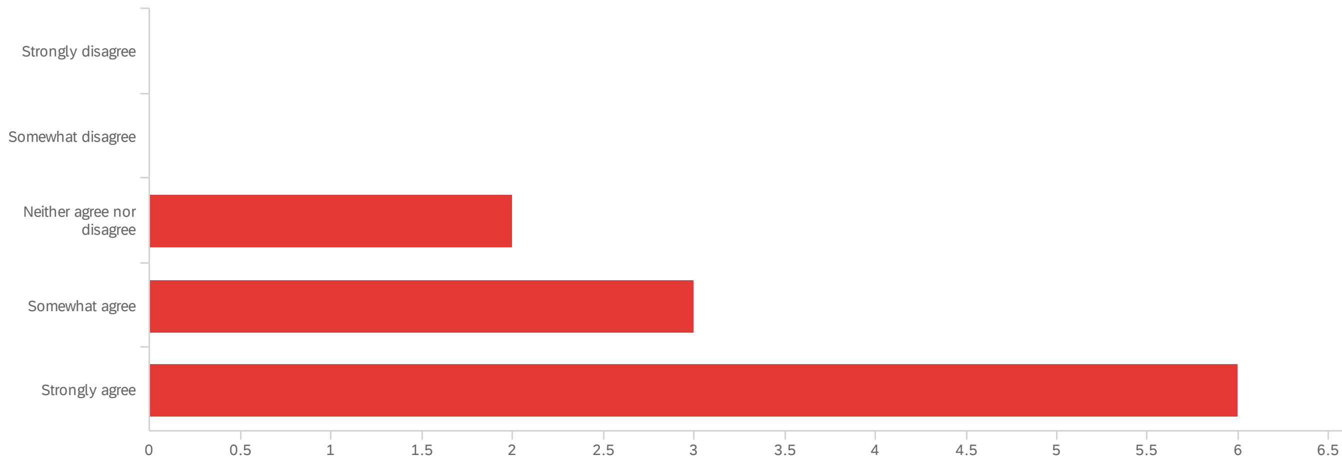


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I was mostly a passive learner for this class during this semester.	1.00	5.00	2.82	1.11	1.24	11

#	Field	Choice Count	
1	Strongly disagree	9.09%	1
2	Somewhat disagree	36.36%	4
3	Neither agree nor disagree	27.27%	3
4	Somewhat agree	18.18%	2
5	Strongly agree	9.09%	1
			11

Showing rows 1 - 6 of 6

Q14 - I paid attention to the lecture most of the time in class.

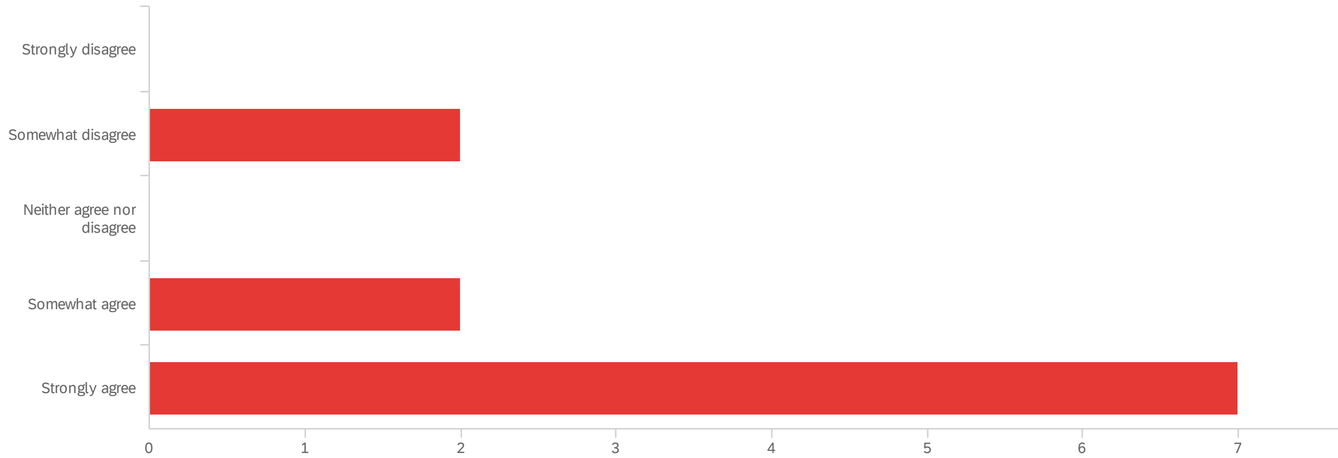


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I paid attention to the lecture most of the time in class.	3.00	5.00	4.36	0.77	0.60	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	0.00%	0
3	Neither agree nor disagree	18.18%	2
4	Somewhat agree	27.27%	3
5	Strongly agree	54.55%	6
			11

Showing rows 1 - 6 of 6

Q15 - I was mostly an active learner for this class during this period.

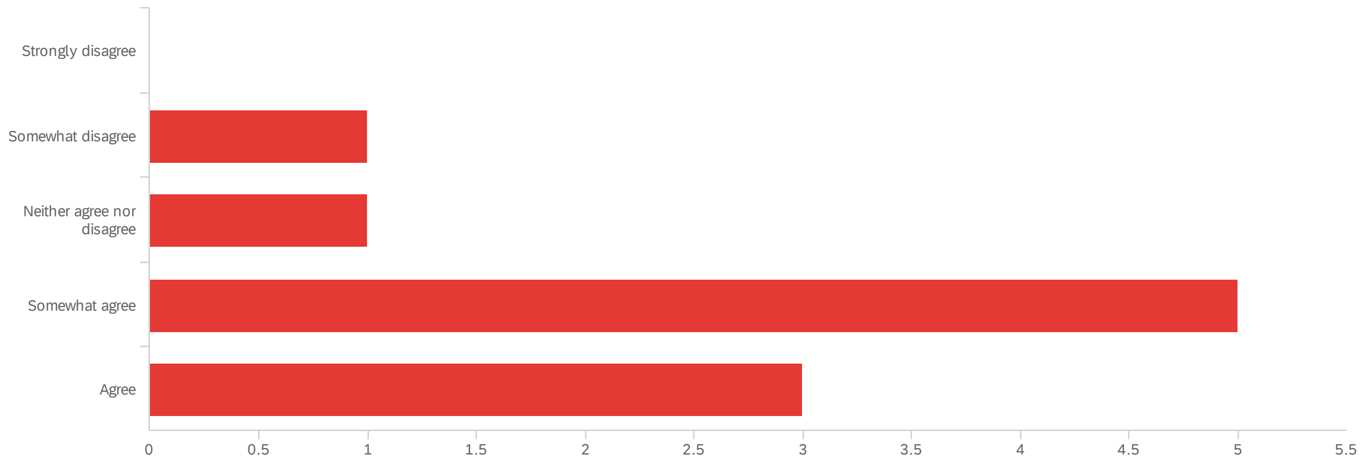


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I was mostly an active learner for this class during this period.	2.00	5.00	4.27	1.14	1.29	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	18.18%	2
5	Strongly agree	63.64%	7
			11

Showing rows 1 - 6 of 6

Q16 - Most students of the whole class were actively involved in class during this semester.

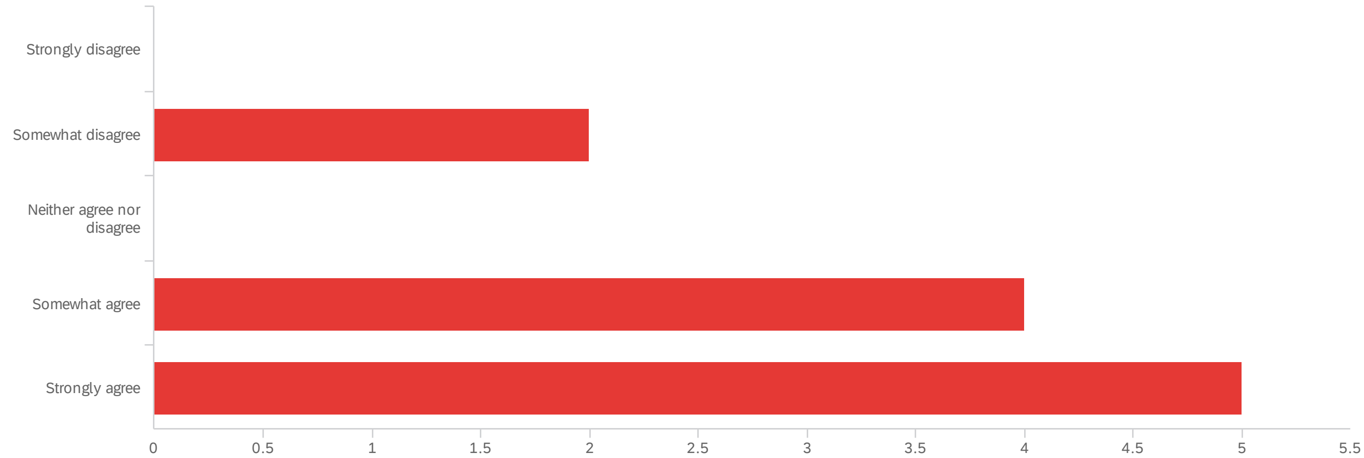


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Most students of the whole class were actively involved in class during this semester.	31.00	35.00	33.80	1.25	1.56	10

#	Field	Choice Count	
30	Strongly disagree	0.00%	0
31	Somewhat disagree	10.00%	1
32	Neither agree nor disagree	10.00%	1
34	Somewhat agree	50.00%	5
35	Agree	30.00%	3
			10

Showing rows 1 - 6 of 6

Q17 - I am confident about the real-world application on the topic of Regression Analysis.

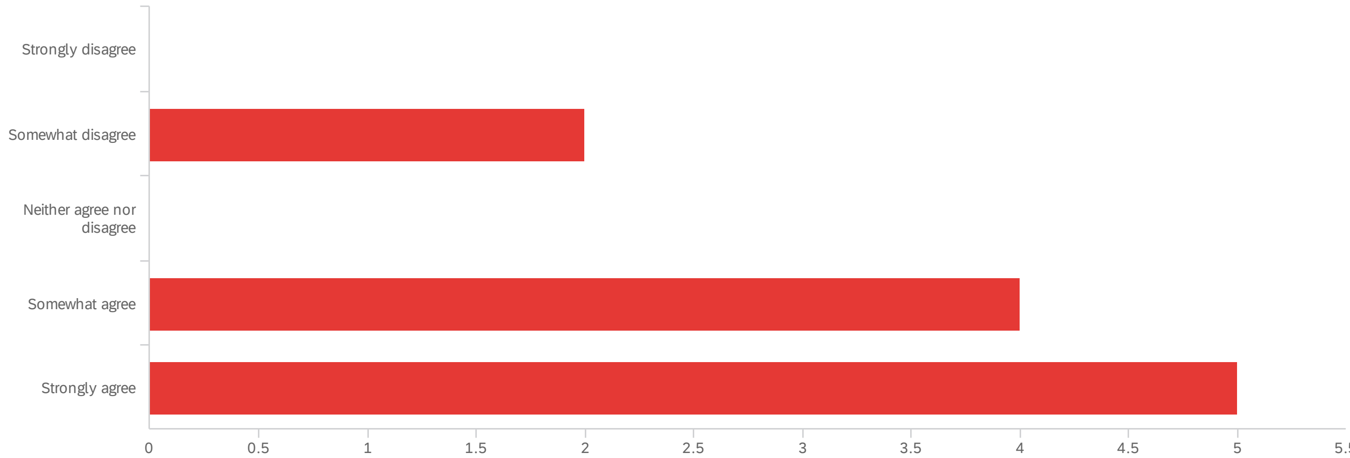


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am confident about the real-world application on the topic of Regression Analysis.	2.00	5.00	4.09	1.08	1.17	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	36.36%	4
5	Strongly agree	45.45%	5
			11

Showing rows 1 - 6 of 6

Q18 - I am confident about the real-world application of general statistics.

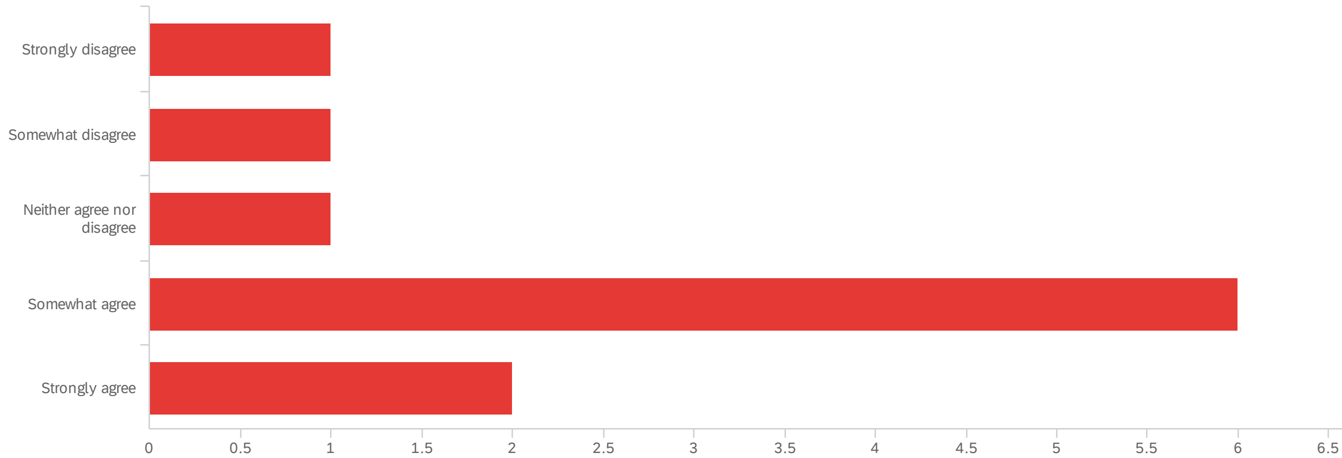


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am confident about the real-world application of general statistics.	2.00	5.00	4.09	1.08	1.17	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	36.36%	4
5	Strongly agree	45.45%	5
			11

Showing rows 1 - 6 of 6

Q19 - I feel confident to explain regression analysis to others.

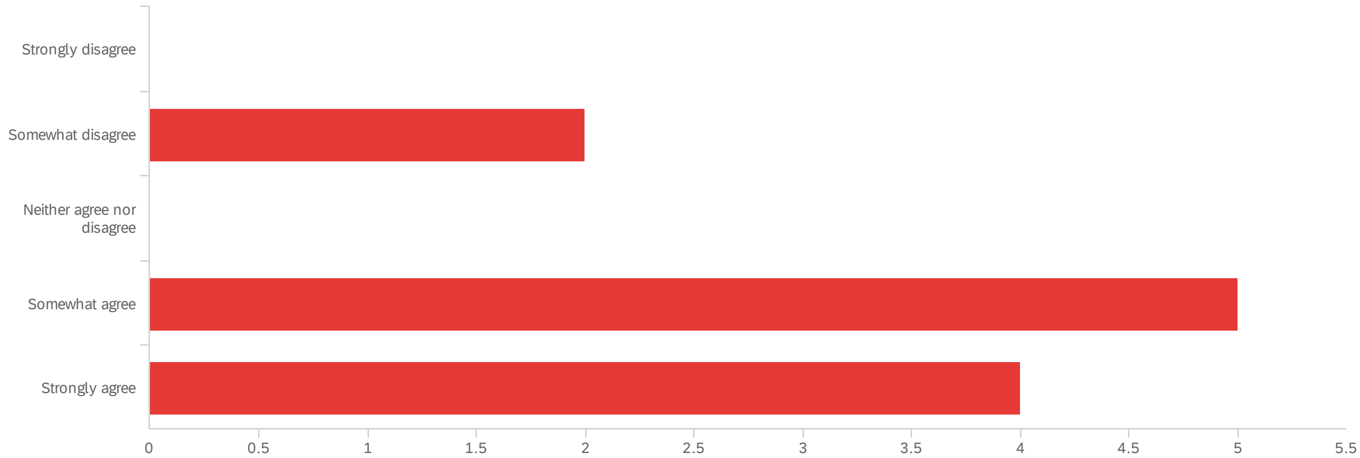


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel confident to explain regression analysis to others.	1.00	5.00	3.64	1.15	1.32	11

#	Field	Choice Count	
1	Strongly disagree	9.09%	1
2	Somewhat disagree	9.09%	1
3	Neither agree nor disagree	9.09%	1
4	Somewhat agree	54.55%	6
5	Strongly agree	18.18%	2
			11

Showing rows 1 - 6 of 6

Q20 - This class helps me improve the oral presentation ability.

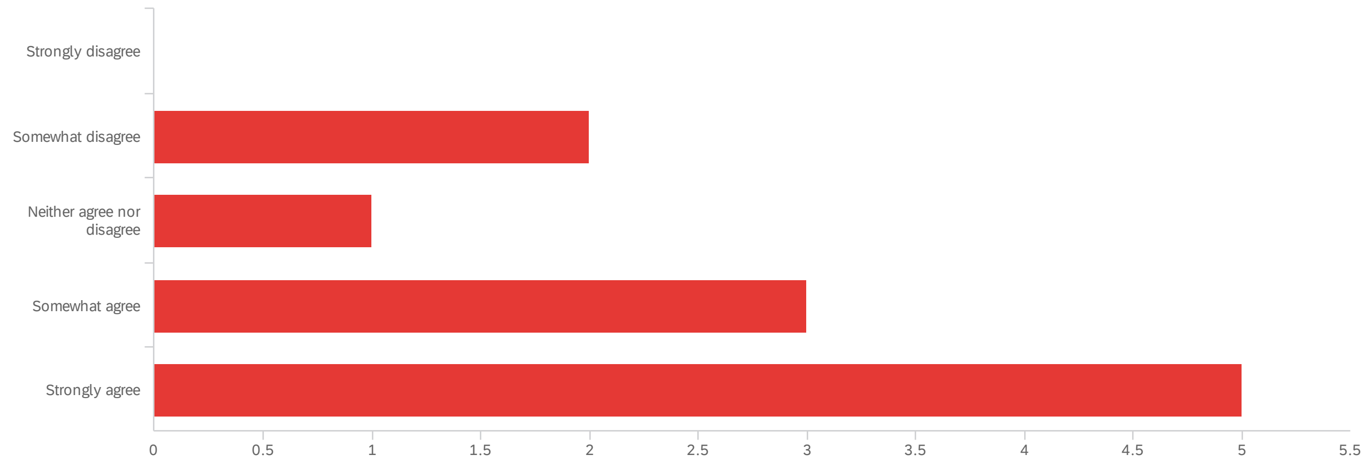


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	This class helps me improve the oral presentation ability.	2.00	5.00	4.00	1.04	1.09	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	45.45%	5
5	Strongly agree	36.36%	4
			11

Showing rows 1 - 6 of 6

Q21 - This class helps me improve problems-solving skills.

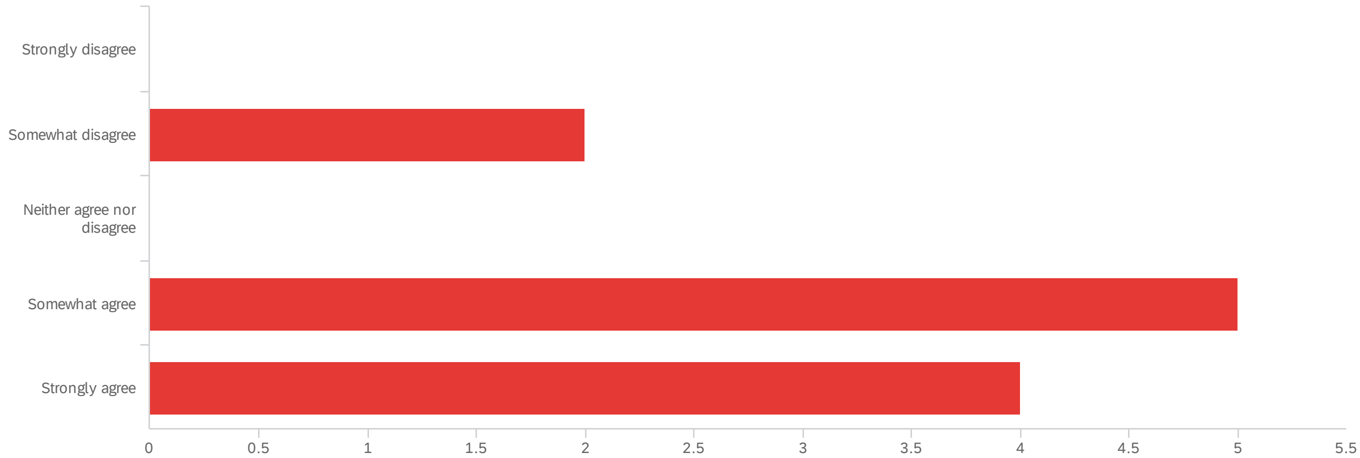


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	This class helps me improve problems-solving skills.	2.00	5.00	4.00	1.13	1.27	11

#	Field		Choice Count
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	9.09%	1
4	Somewhat agree	27.27%	3
5	Strongly agree	45.45%	5
			11

Showing rows 1 - 6 of 6

Q22 - I am able to connect the lecture concepts to their usage.

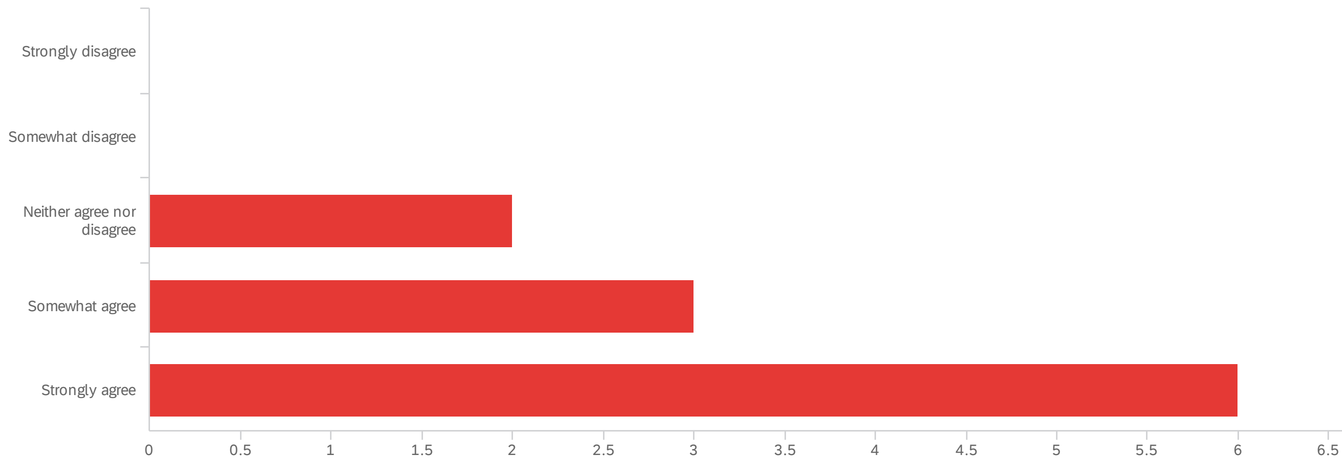


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am able to connect the lecture concepts to their usage.	2.00	5.00	4.00	1.04	1.09	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	45.45%	5
5	Strongly agree	36.36%	4
			11

Showing rows 1 - 6 of 6

Q23 - I would like to recommend this class to other students.

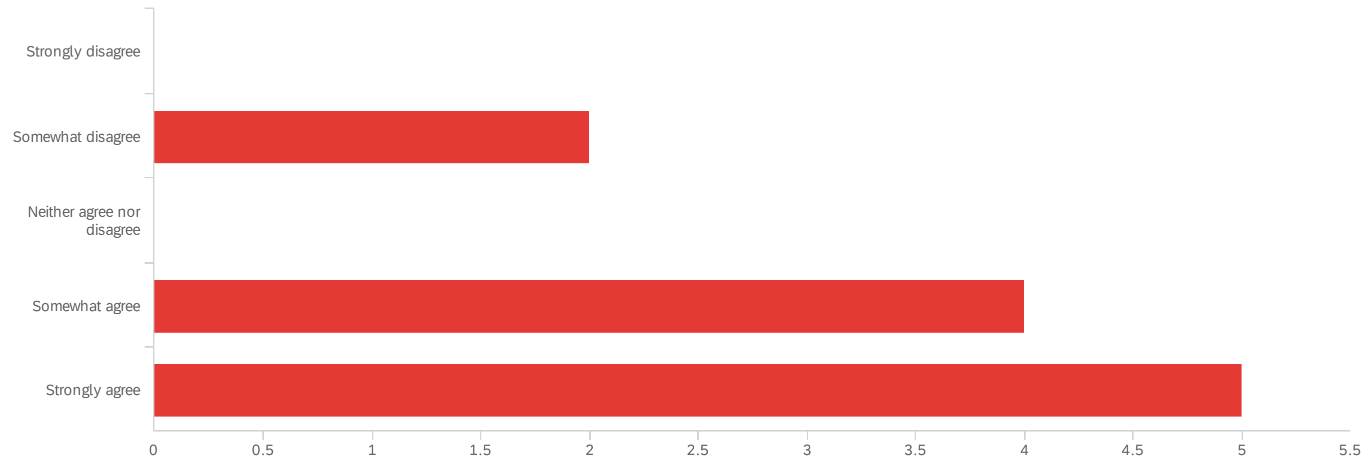


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I would like to recommend this class to other students.	3.00	5.00	4.36	0.77	0.60	11

#	Field		Choice Count
1	Strongly disagree	0.00%	0
2	Somewhat disagree	0.00%	0
3	Neither agree nor disagree	18.18%	2
4	Somewhat agree	27.27%	3
5	Strongly agree	54.55%	6
			11

Showing rows 1 - 6 of 6

Q24 - I feel engaged/ involved during this period of study.

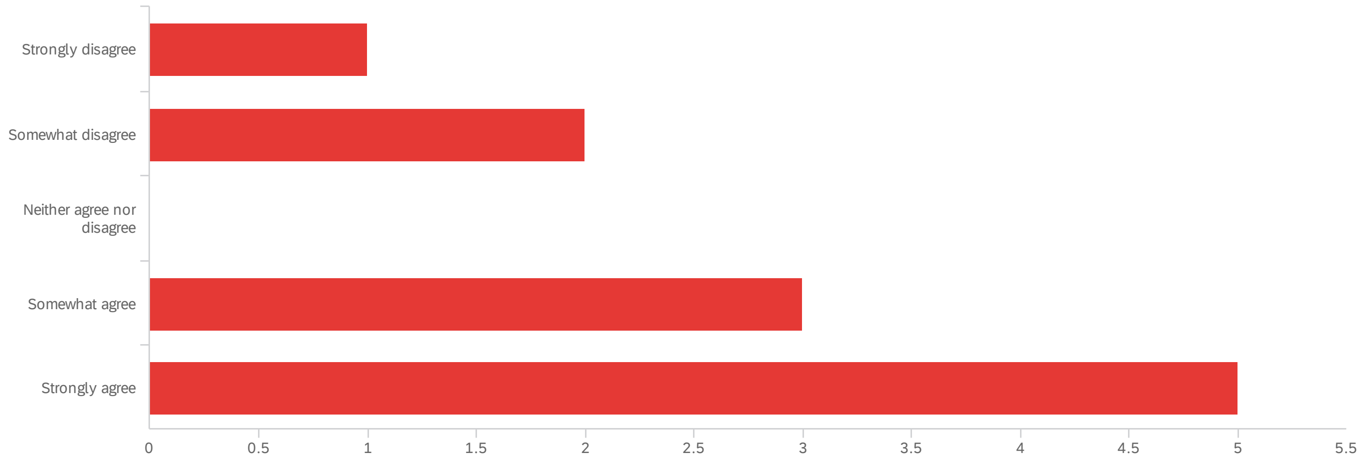


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel engaged/ involved during this period of study.	7.00	10.00	9.09	1.08	1.17	11

#	Field		Choice Count
6	Strongly disagree	0.00%	0
7	Somewhat disagree	18.18%	2
8	Neither agree nor disagree	0.00%	0
9	Somewhat agree	36.36%	4
10	Strongly agree	45.45%	5
			11

Showing rows 1 - 6 of 6

Q25 - This class helps me improve the ability to work as a team.

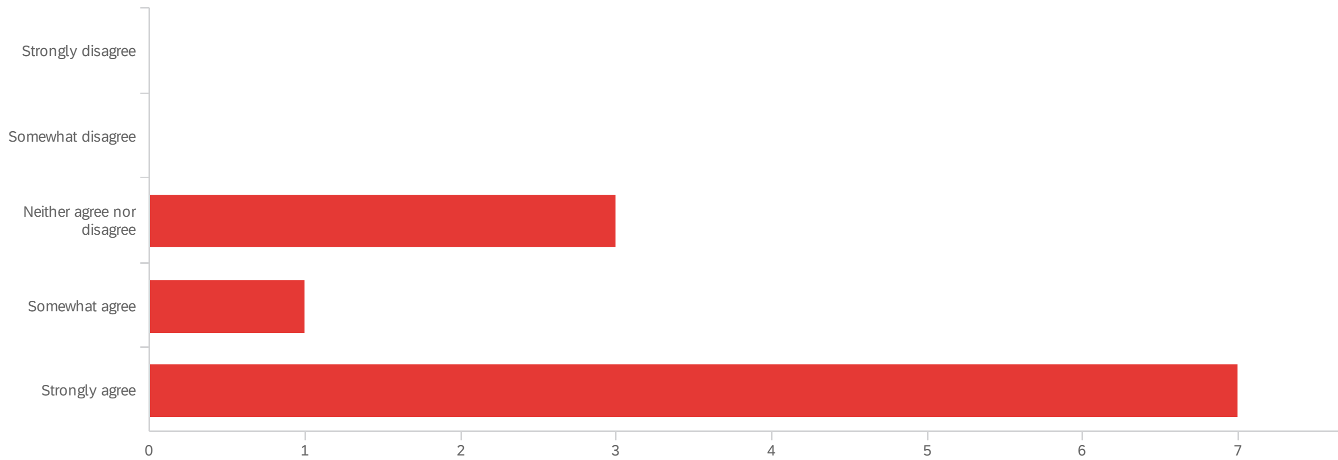


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	This class helps me improve the ability to work as a team.	1.00	5.00	3.82	1.40	1.97	11

#	Field	Choice Count	
1	Strongly disagree	9.09%	1
2	Somewhat disagree	18.18%	2
3	Neither agree nor disagree	0.00%	0
4	Somewhat agree	27.27%	3
5	Strongly agree	45.45%	5
			11

Showing rows 1 - 6 of 6

Q26 - Discussing the course materials in class with other students helps me to understand the concepts.

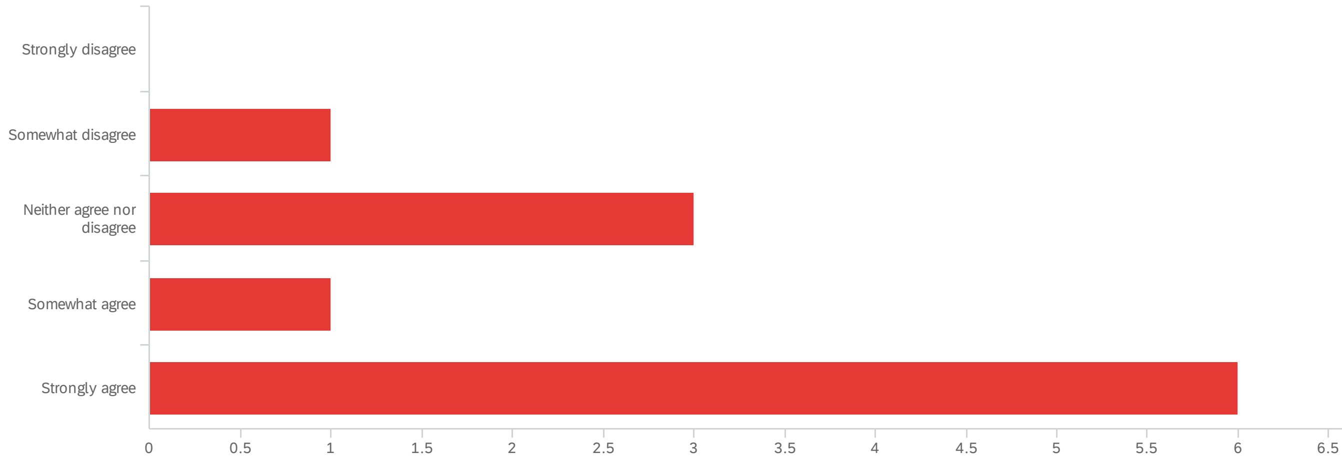


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Discussing the course materials in class with other students helps me to understand the concepts.	3.00	5.00	4.36	0.88	0.78	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	0.00%	0
3	Neither agree nor disagree	27.27%	3
4	Somewhat agree	9.09%	1
5	Strongly agree	63.64%	7
			11

Showing rows 1 - 6 of 6

Q27 - The classroom set-up helps in learning the materials this semester.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The classroom set-up helps in learning the materials this semester.	2.00	5.00	4.09	1.08	1.17	11

#	Field	Choice Count	
1	Strongly disagree	0.00%	0
2	Somewhat disagree	9.09%	1
3	Neither agree nor disagree	27.27%	3
4	Somewhat agree	9.09%	1
5	Strongly agree	54.55%	6
			11

Showing rows 1 - 6 of 6

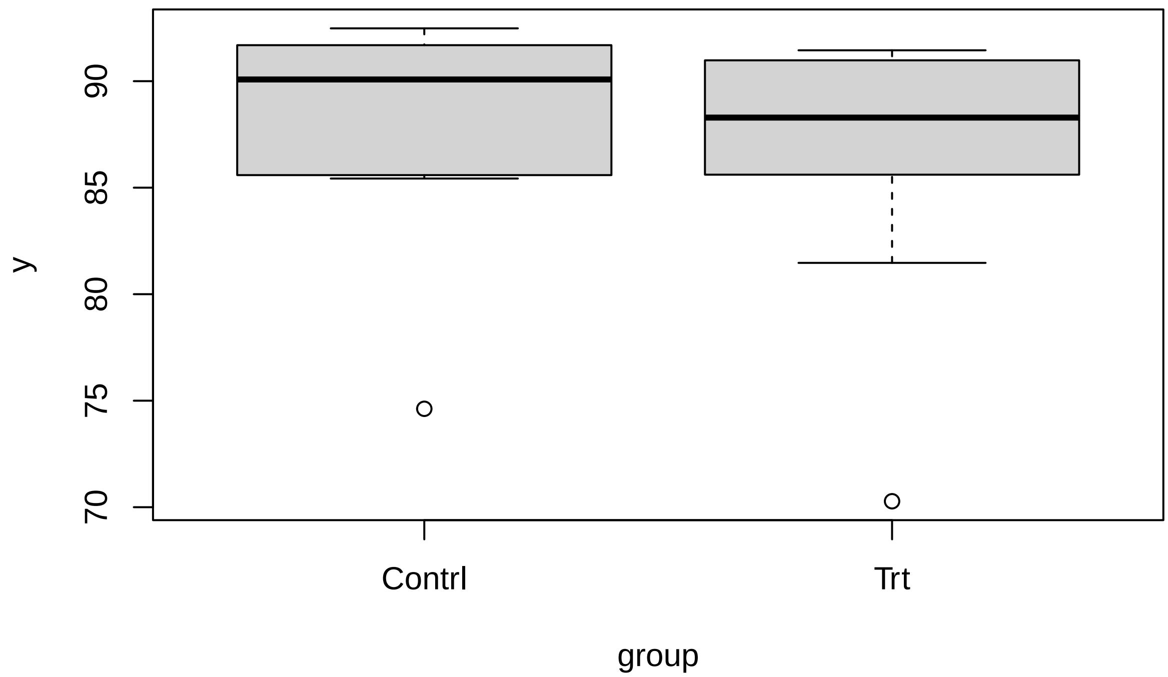
End of Report

Appendix IV. R code and outputs

```
trt = c(90.98,91.01,87.72,81.47,86.57,85.61,91.45,89.43,70.28,88.86)
contr = c(90.33,85.75,89.83,92.05,74.62,85.43,92.48,91.33)
y = c(trt,contr)
group = c(rep("Trt",length(trt)),rep("Contrl",length(contr)))
data = cbind.data.frame(y,group)
data
```

```
##        y  group
## 1  90.98    Trt
## 2  91.01    Trt
## 3  87.72    Trt
## 4  81.47    Trt
## 5  86.57    Trt
## 6  85.61    Trt
## 7  91.45    Trt
## 8  89.43    Trt
## 9  70.28    Trt
## 10 88.86    Trt
## 11 90.33 Contrl
## 12 85.75 Contrl
## 13 89.83 Contrl
## 14 92.05 Contrl
## 15 74.62 Contrl
## 16 85.43 Contrl
## 17 92.48 Contrl
## 18 91.33 Contrl
```

```
boxplot(y~group)
```




```
bartlett.test(y~group)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  y by group
## Bartlett's K-squared = 0.043384, df = 1, p-value = 0.835
```

```
test = aov(y~group,data=data)
summary(test)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## group        1    8.6    8.58   0.223  0.643
## Residuals   16  615.9   38.49
```

```
kruskal.test(y~group)
```

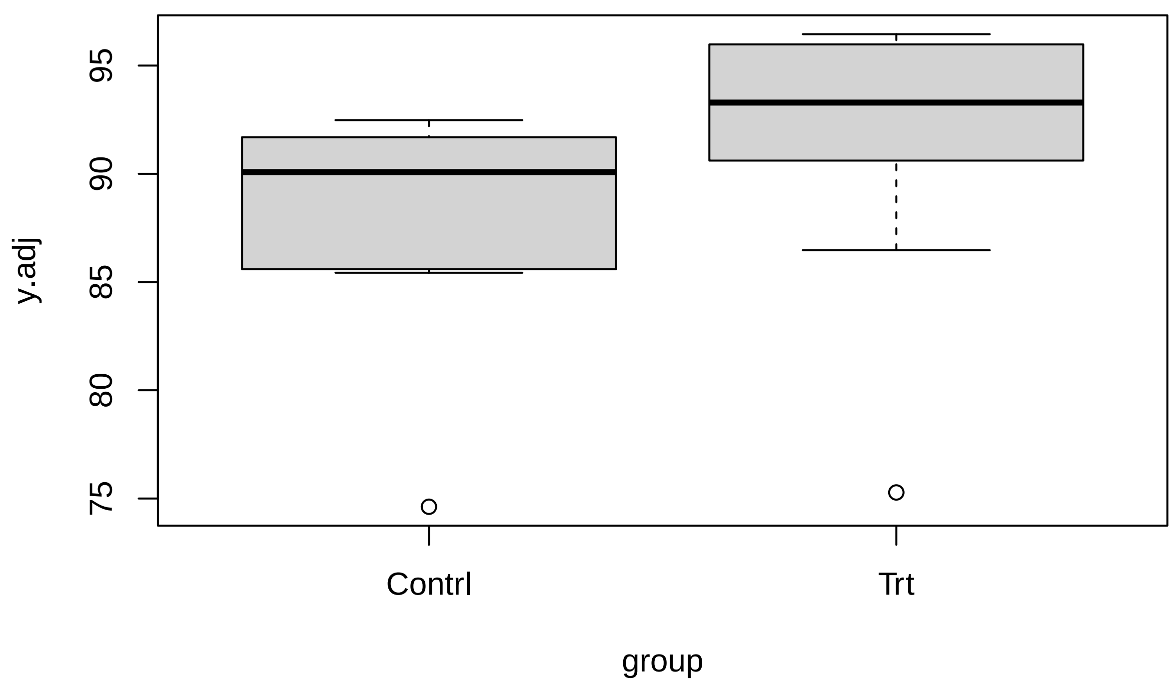
```
##
##  Kruskal-Wallis rank sum test
##
## data:  y by group
## Kruskal-Wallis chi-squared = 0.63947, df = 1, p-value = 0.4239
```

```
trt.adj = trt + 5
y.adj = c(trt.adj, contr)
data.adj = cbind.data.frame(y.adj,group)
data.adj
```

```
##    y.adj  group
```

```
## 1  95.98    Trt
## 2  96.01    Trt
## 3  92.72    Trt
## 4  86.47    Trt
## 5  91.57    Trt
## 6  90.61    Trt
## 7  96.45    Trt
## 8  94.43    Trt
## 9  75.28    Trt
## 10 93.86    Trt
## 11 90.33 Contrl
## 12 85.75 Contrl
## 13 89.83 Contrl
## 14 92.05 Contrl
## 15 74.62 Contrl
## 16 85.43 Contrl
## 17 92.48 Contrl
## 18 91.33 Contrl
```

```
boxplot(y.adj~group)
```




```
bartlett.test(y.adj~group)
```

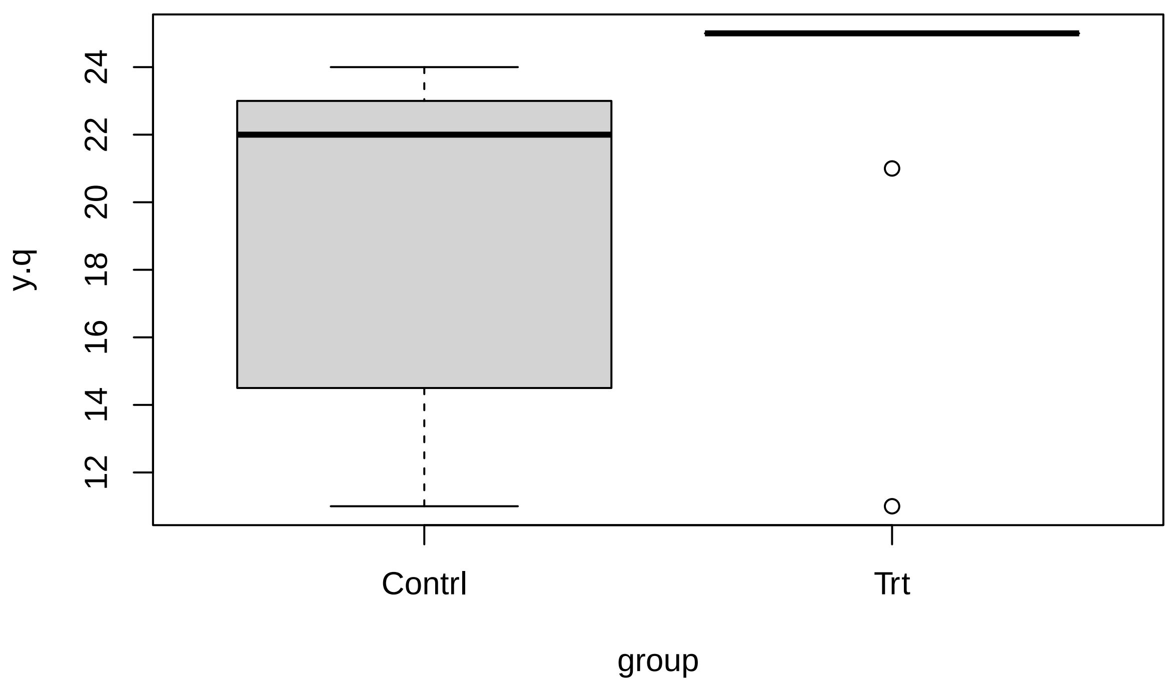
```
##
##  Bartlett test of homogeneity of variances
##
## data:  y.adj by group
```

```
## Bartlett's K-squared = 0.043384, df = 1, p-value = 0.835
```

```
kruskal.test(y.adj~group)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  y.adj by group
## Kruskal-Wallis chi-squared = 4.1763, df = 1, p-value = 0.04099
```

```
q.trt = c(25,25,25,25,21,25,25,25,11,25)
q.ctl = c(23,16,22,24,11,13,22,23)
y.q = c(q.trt, q.ctl)
data.q = cbind.data.frame(y.q, group)
boxplot(y.q~group)
```




```
kruskal.test(y.q~group)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  y.q by group
## Kruskal-Wallis chi-squared = 6.5593, df = 1, p-value = 0.01043
```