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STAT 8760 Sample Surveys
Final Project Fall 2019

Estimating Mean Study Time for UL MILE Students

Introduction

Every semester at Georgia State University, new students walk into the computer lab in the Urban Life building, room 301, for the first time. They will then spend a lot of time there during the rest of the semester as required for either MATH 0999 (Support for College Algebra), MATH 1111 (College Algebra), or MATH 1113 (Precalculus). Once in the lab, students then log in to a computer and use the website “MyLab | Math” from the company Pearson for their homework, quizzes, and even exams. The subject of Mathematics is definitely not a spectator sport, and the famous saying “practice makes perfect” applies perfectly into learning/understanding the many different concepts. This is why students in these 3 classes meet in the UL MILE lab 2 times a week, and only once per week in the classroom with their instructor.

Our main objective is to give an estimate of the mean number of hours studied by a student who is enrolled in MATH 1111 or MATH 1113 for their third exam. Students can use multiple resources at their disposal for this, including review sessions, the online Test Review, the Mathematics Assistance Complex, etc.

Methodology

Our target population is of course all GSU students who are enrolled in MATH 0999, MATH 1111, or MATH 1113 for Fall 2019. We obtained the population size for MATH0999/MATH1111 as $N_1 = 1145$, and the population size for MATH 1113 as $N_2 = 416$. Thus our total population $N = 1561$.

For our survey design, we chose to do a stratified random sample as our sampling method. This is due to the fact that the class that each student is taking can act as a natural subgroup/divider. Thus, we have 2 stratums to sample from. The reason there is only 2 and not 3 different stratums is that students in MATH 1111 may or may not also be enrolled in MATH 0999, for which the GSU catalog description states: “this course is intended to provide corequisite support for students requiring remediation in mathematics while they are enrolled in MATH 1111, College Algebra.” Thus, due to this possible overlap we cannot use MATH 0999 as a third stratum.

To start, we wanted to calculate the minimum sample size required to estimate the mean number of hours studied within an error bound of 0.5 hours, or within 30 minutes, with a probability of 0.95. We used the formula below to achieve this.

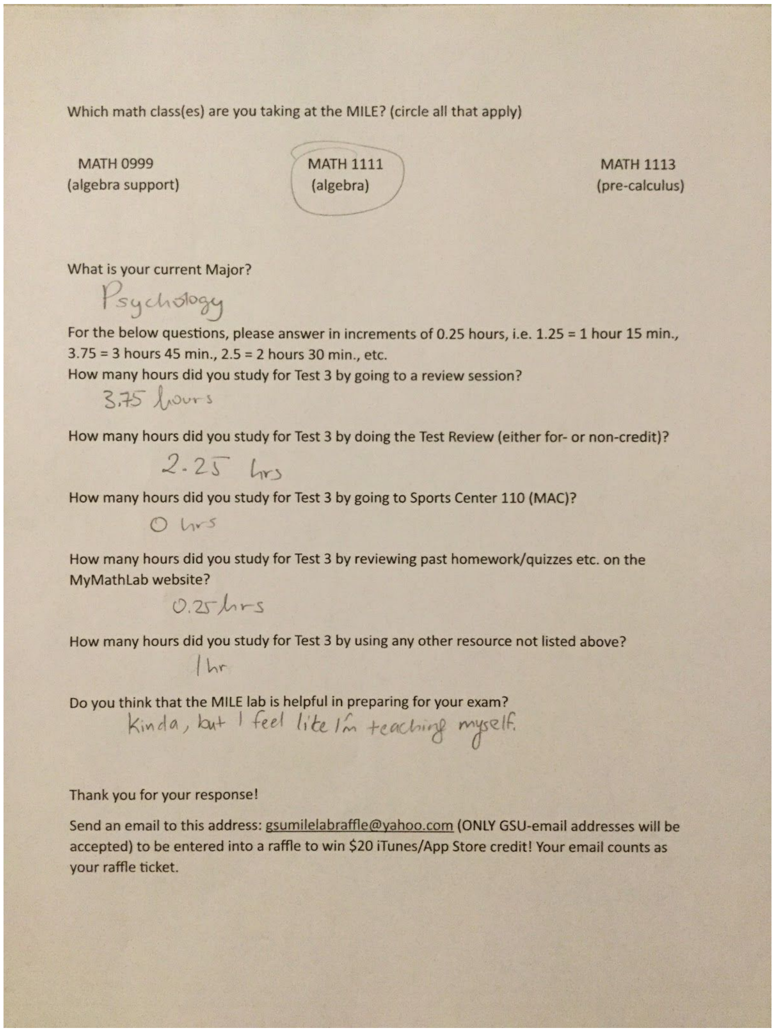
$$n = \frac{\sum_{i=1}^{L} N_i^2 \sigma_i^2 / w_i}{(N^2 D + \sum_{i=1}^{L} N_i \sigma_i^2)}, \quad D = \frac{B^2}{z_{1-\frac{\alpha}{2}}^2}$$

Where $i = 1$ is the MATH 1111 stratum, and $i = 2$ is the MATH 1113 stratum.

A small initial pilot study was conducted and we used the results from those to obtain $\sigma_1^2 = 17.23386$, and $\sigma_2^2 = 11.79957$. Using these values for sigma, we determined that a minimum sample size of 210 would be required to estimate the mean total hours studied within an error bound of B = 0.5 (30 minutes) and with 95% confidence.

$$n_i = n \frac{N_i \sigma_i}{\sum_{i=1}^{L} N_i \sigma_i}, i = 1, L$$

We then needed to find the optimal allocation scheme to use, and since the variance differs among each stratum and we assume the cost to administer the survey is the same in each stratum, we used Neyman allocation. Using the above formula, we obtained that $n_1 = 161$, and $n_2 = 49$.



Which math class(es) are you taking at the MILE? (circle all that apply)

MATH 0999 (algebra support) | MATH 1111 (algebra) | MATH 1113 (pre-calculus)

What is your current Major?

Psychology

For the below questions, please answer in increments of 0.25 hours, i.e. 1.25 = 1 hour 15 min., 3.75 = 3 hours 45 min., 2.5 = 2 hours 30 min., etc.

How many hours did you study for Test 3 by going to a review session?

3.75 hours

How many hours did you study for Test 3 by doing the Test Review (either for- or non-credit)?

2.25 hrs

How many hours did you study for Test 3 by going to Sports Center 110 (MAC)?

0 hrs

How many hours did you study for Test 3 by reviewing past homework/quizzes etc. on the MyMathLab website?

0.25 hrs

How many hours did you study for Test 3 by using any other resource not listed above?

1 hr

Do you think that the MILE lab is helpful in preparing for your exam?

Kinda, but I feel like I'm teaching myself.

Thank you for your response!

Send an email to this address: gsumilelabraffle@yahoo.com (ONLY GSU-email addresses will be accepted) to be entered into a raffle to win $20 iTunes/App Store credit! Your email counts as your raffle ticket.

The final survey layout/questions

For the survey question design, the first question is obviously which class(es) that they take in the MILE. Students that responded with any combination of MATH 0999 or MATH 1111 were divided into one stratum and those that responded with MATH 1113 were divided into the second stratum. We then thought it would be a good idea to include their current major/area of concentration of study as it could be interesting to compare the differences in the number of hours studied in each different major/field, if any. Initially, we thought to ask their gender as another demographic question but decided to remove that question in the final survey.

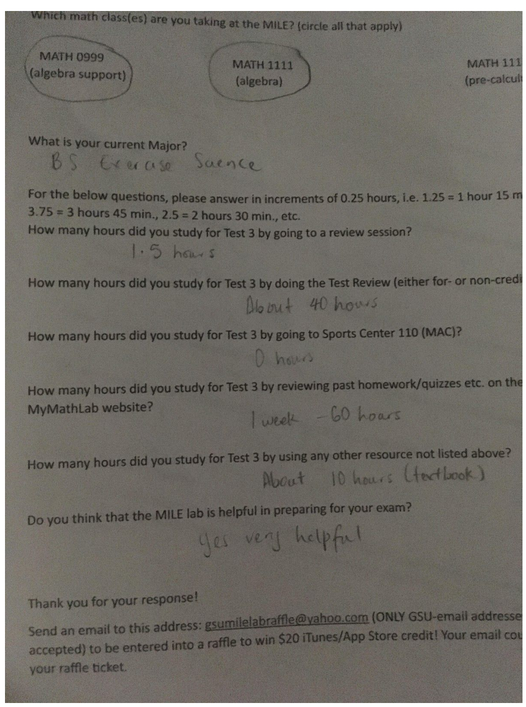
For the next 5 questions, we listed all the different resources that the students could have used to study/prepare for their exam. We thought it would be a good idea to indicate that their responses should be in increments of 0.25 hours to remove possible sources of error. The following list the different resources at the students' disposal in exam preparation:

- There are multiple review sessions each with a scheduled length of 1 hour and 15 minutes that are held by lab assistants or instructors the week leading up to each exam.
- There is a Test Review assignment on the MyLab Math website from Pearson that provides an overview of the type of problems that will likely be on the next exam.
- The Mathematics Assistance Complex (MAC) offers walk-in tutoring to any GSU student for numerous courses in MATH.
- The online homework, quizzes, etc. from the MyLab Math website are also a good resource to review concepts/problems that may appear on their next exam.
- The last question asks to give an estimate of how many hours they studied using any resource that is not listed above (YouTube videos, khanacademy, etc.).

We then created a new variable which measures the students' total number of hours studied by summing the number of hours in these 5 questions listed above. Lastly, we included a binary response question to indicate whether the student finds their time in the MILE lab to be helpful in exam preparation. As can be seen from a response to the survey above, some students did not provide a clear "yes" or "no" response, and we had to create a new group labeled as "maybe." At the end of the survey, we thought it would be nice to include an incentive to respond.

To see if there is a difference between 1111 students' satisfaction and 0999 students' satisfaction with the MILE, z-scores will be calculated from the pooled proportions of satisfaction.

Data Analysis/Results


Which math class(es) are you taking at the MILE? (circle all that apply)

MATH 0999 (algebra support)   MATH 1111 (algebra)   MATH 111 (pre-calcul

What is your current Major?

BS Exercise Science

For the below questions, please answer in increments of 0.25 hours, i.e. 1.25 = 1 hour 15 m
3.75 = 3 hours 45 min., 2.5 = 2 hours 30 min., etc.

How many hours did you study for Test 3 by going to a review session?

1.5 hours

How many hours did you study for Test 3 by doing the Test Review (either for- or non-credi

About 40 hours

How many hours did you study for Test 3 by going to Sports Center 110 (MAC)?

0 hours

How many hours did you study for Test 3 by reviewing past homework/quizzes etc. on the MyMathLab website?

1 week - 60 hours

How many hours did you study for Test 3 by using any other resource not listed above?

About 10 hours (textbook)

Do you think that the MILE lab is helpful in preparing for your exam?

yes very helpful

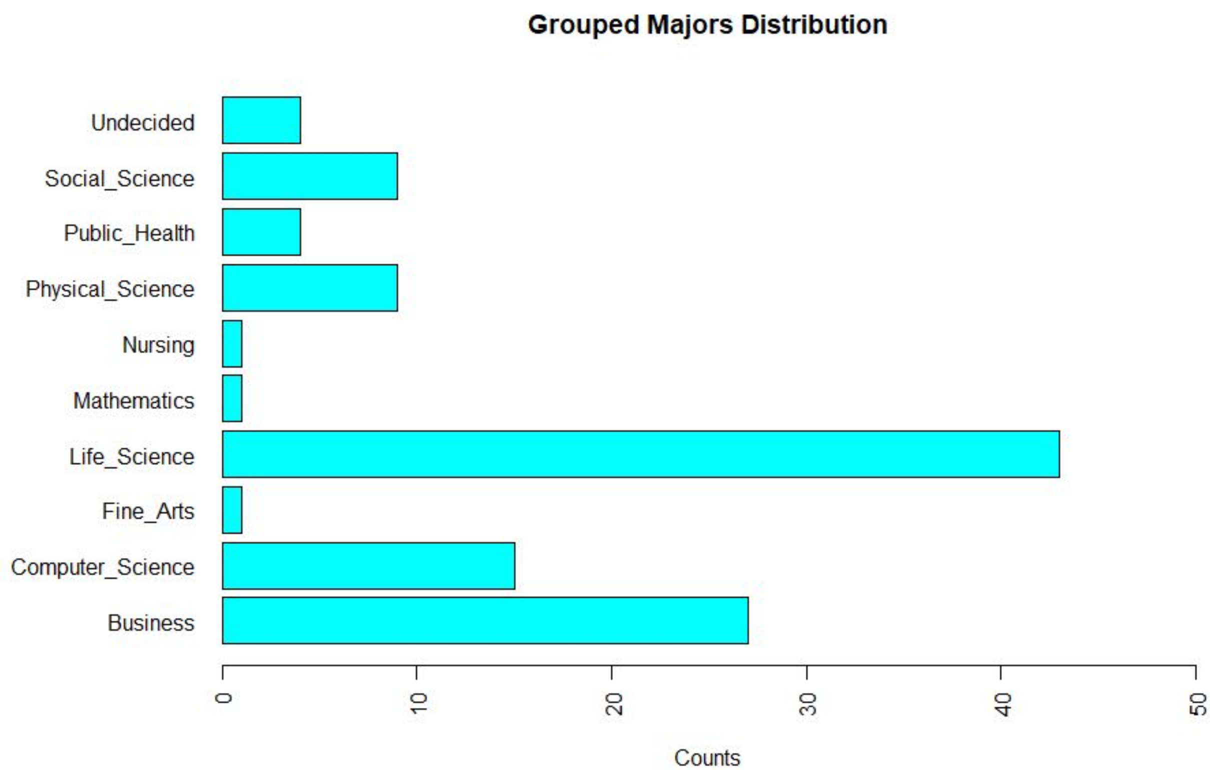
Thank you for your response!

Send an email to this address: gsumilelabraffle@yahoo.com (ONLY GSU-email addresse accepted) to be entered into a raffle to win $20 iTunes/App Store credit! Your email cou your raffle ticket.

Example of an unusable/discarded response

In the end, due to limitations and time constraints we were unable to obtain a sample size of at least 210 to estimate the mean number of hours studied within an error bound of 0.5 hours (30 minutes). We also discarded a few invalid responses (an example of which is shown in the picture above). Our final sample size was n = 114, with n_1 = 65, and n_2 = 49. Using the sigma values from the pilot survey, we found that if we set the error bound B = 0.85 hours (51 minutes), the minimum sample size is 80, with the allocation scheme of n_1 = 61, and n_2 = 19.

For our demographic question asking for major, we decided to group responses in the same area/field of study together, and the below plot shows their distribution.



Interestingly, biology was the most selected individual major, with 33 responses, followed by computer science with 15 responses, and the third most selected individual major was psychology with 6 responses. Nursing, mathematics, and fine arts each only had 1 response, and we could not find a similar group to include these in.

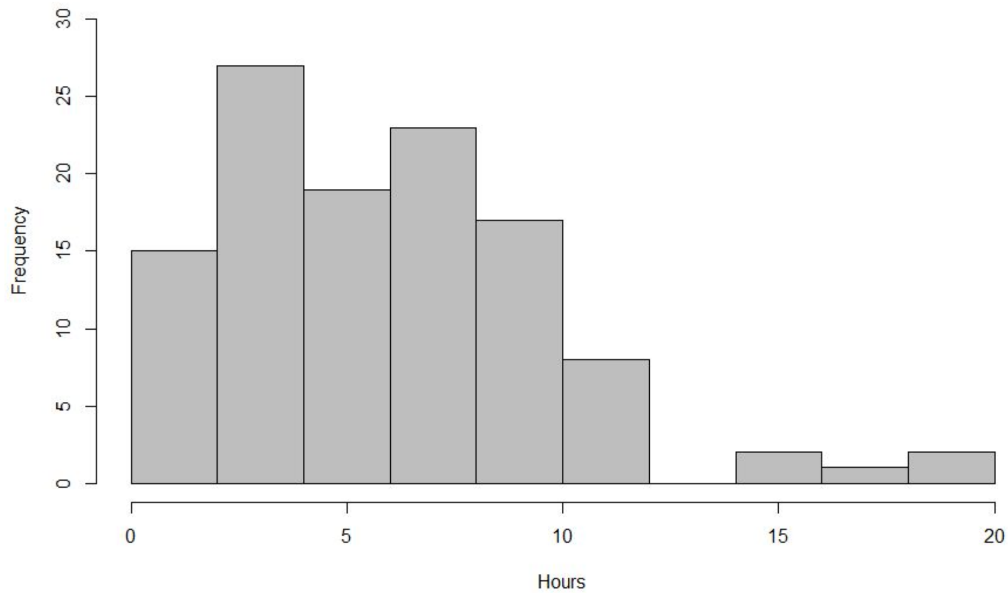
Next, after summing up all the responses to the 5 questions asking about hours studied using different resources, we obtained summary statistics for these in each stratum, shown in the table below:

Class	n	Min.	Median	Max.	Mean	Standard dev.
All	114	0	5.5	20	6.229	3.85
MATH 1111 Total	65	0	5.5	20	6.102	4.15
MATH 1111 Only	38	0	5.625	16	5.761	3.69
MATH 0999	27	1.25	5.5	20	6.583	4.76
MATH 1113	49	0.75	5.5	16.5	6.396	3.44

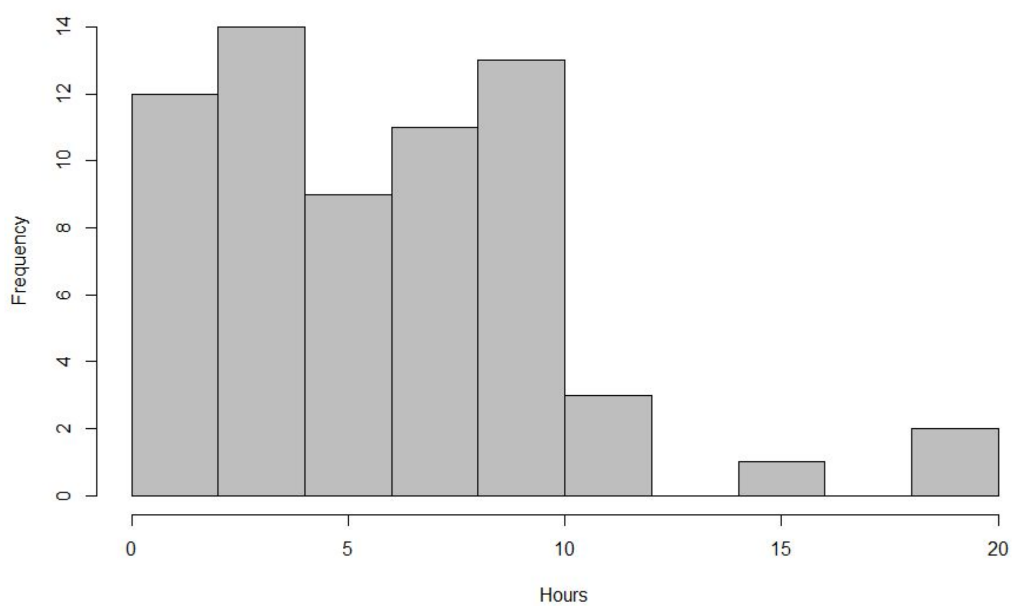
$$\bar{y}_{st} = \sum_{i=1}^{L} \frac{N_i}{N} \bar{y}_i$$

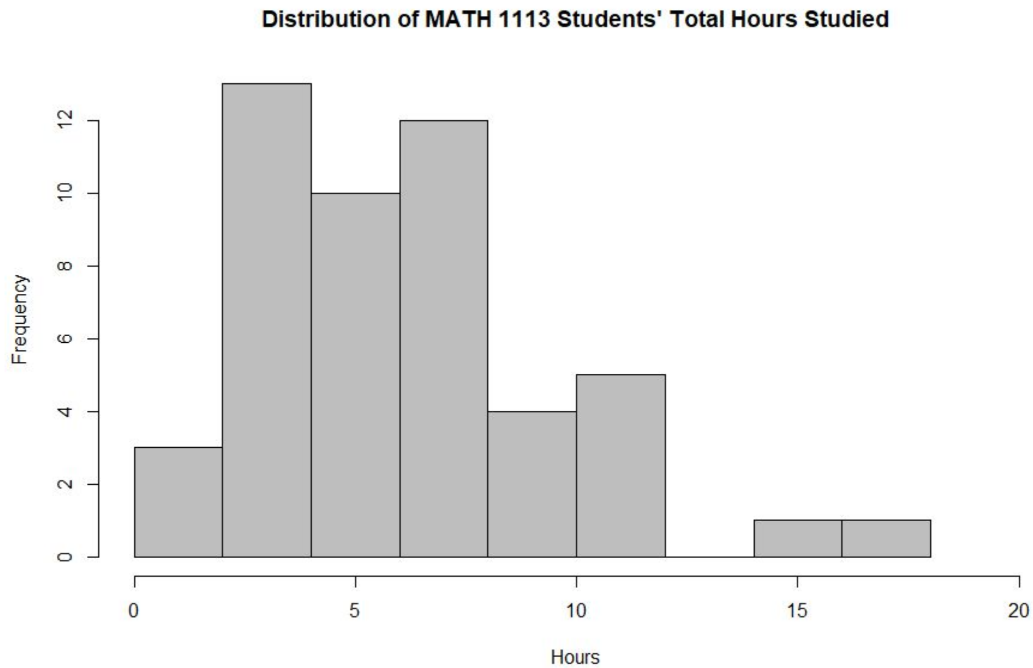
We then used the equation above and obtained our overall stratified sample mean total number of hours studied as 6.180554 hours. Upon checking the overall distribution of the total number of hours studied, we found that they were all mostly right skewed as can be seen in the graphs below:

Distribution of All Students' Total Hours Studied

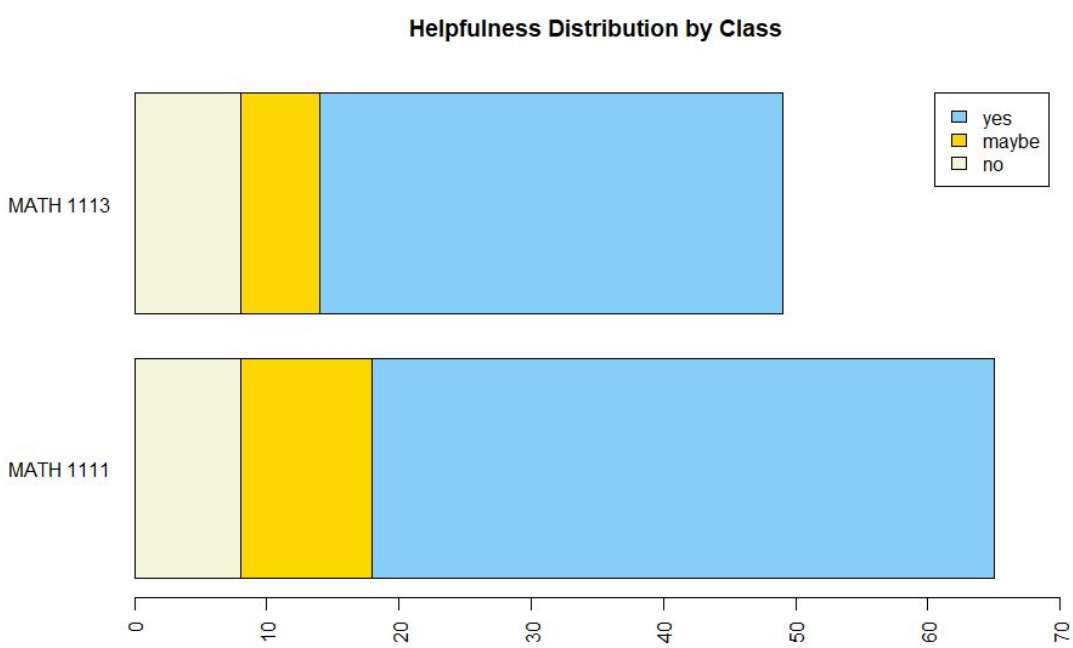


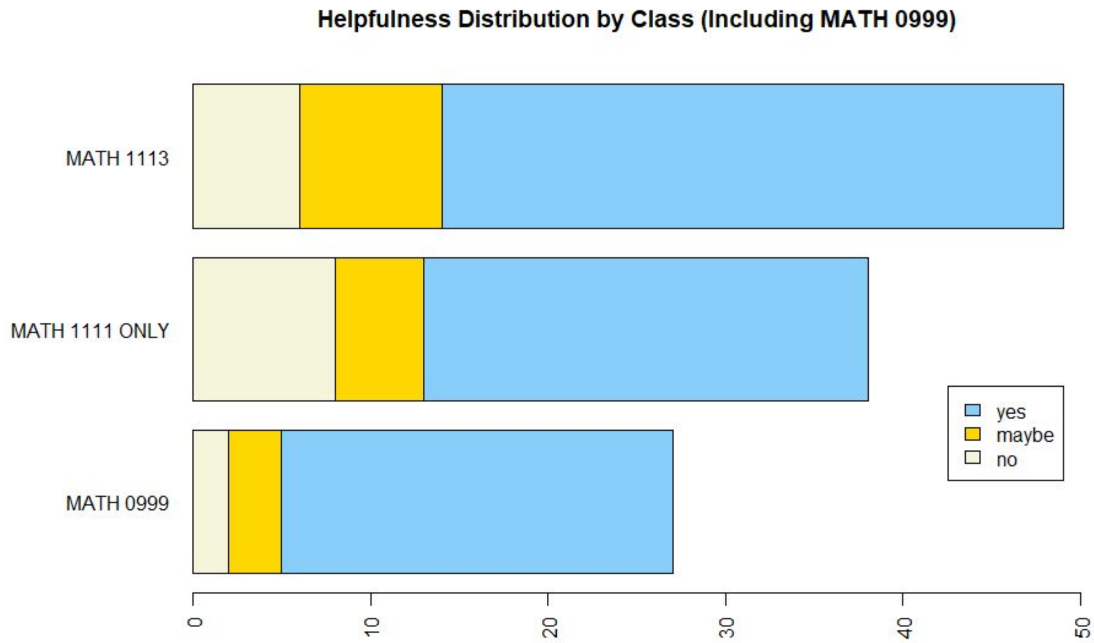
Distribution of MATH 1111 Students' Total Hours Studied





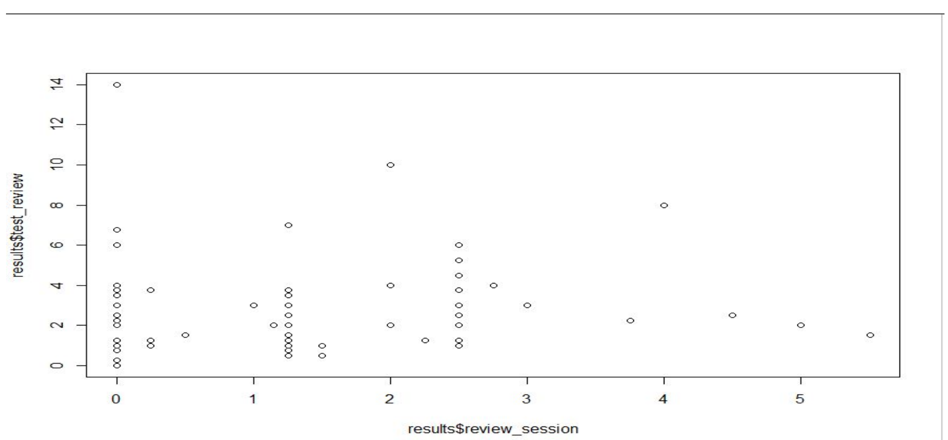
Our last and final question asked the students to indicate whether or not they felt that their time in the MILE lab was helpful for them in preparing for exams, and the below plots show the results:





The above graph separates the MATH 1111 stratum into students who are cross-registered in MATH 0999, and those who are not in MATH 0999 (Support for College Algebra). The majority in each class answered "yes," while the number of unsure responses ("maybe") occurred most in MATH 1113 (Precalculus), and the class with the majority of "no" responses were those who are enrolled only in MATH 1111 (College Algebra).

In order to see if our estimates could be complemented by either ratio or regression estimators, we plotted several scatterplots of the variables to see any possible correlations that could help us. Unfortunately, no such correlations existed, with an example shown below.



Scatterplot of review session hours versus test_review hours. Since there is not a linear correlation, ratio/regression estimators will not be useful.

Our analysis produced the following tables of results:

Mean Estimate of Hours Studied	Mean Estimate	Variance	Confidence Interval
Review_Session	0.56	0.01	[0.38, 0.75]
Test_Review	1.69	0.03	[1.37, 2.01]
MAC	0.11	0.002	[0.02, 0.20]
Past_HW_Quiz	1.25	0.02	[0.98, 1.51]
Other	0.55	0.01	[0.35, 0.75]

Satisfaction Proportion Estimation	Estimate	Variance	Confidence Interval
Satisfied	0.48	0.001	[0.41, 0.56]
Mixed Satisfaction	0.10	0.001	[0.05, 0.14]
Dissatisfied	0.09	0.01	[0.05, 0.13]

Satisfaction Proportion Confidence Based on 0999 and 1111 Students	0999	1111
Satisfied	[0.67, 0.96]	[0.51, 0.81]
Mixed Satisfaction	[-0.02, 0.17]	[0.13, 0.29]
Dissatisfied	[-0.004, 0.23]	[0.03, 0.23]

P-values of Difference in Satisfaction between 0999 and 111 students	95% confidence p-value
Satisfied	0.16
Mixed Satisfaction	0.13
Dissatisfied	0.80

Discussion

Students appear to utilize their past homework/quizzes, and also the test reviews provided by Pearson to study for their exam 3. On the other hand, the MAC was very underutilized as a service, the reason why being out of the scope of this report. Satisfaction overall with the MILE is generally positive, especially among 0999 and 1111 students. Although 0999 students use the MILE more than 1111 students due to their program structure, there is no current evidence that there is a difference in satisfaction between the two courses.

Conclusion

Students in the MILE have wide variations in their study time for Test 3. In the future a wider sample size should be taken. Additionally, a natural question to ask is if these estimates are consistent throughout the semester, and if they change, how? Additionally, these results will be shared with the supervisors of the MILE, with a discussion on possible conclusions. The hope of course is that the MILE reads the comments of these students more in-depth in order to have the most engagement with them as possible.

Appendix R Code

```
> source('~/STAT_HW/Sem3/SampleSurvey/Project.R', echo=TRUE)

> library(stringr)
> results =
read.csv("C:\\Users\\norie\\OneDrive\\Documents\\STAT_HW\\Sem3\\SampleSurvey\\results.csv")

> results$helpful.normalized. = str_replace_all(results$helpful.normalized., "[\r\n]" , "")

> results$Major = str_replace_all(results$Major, "[\r\n]" , "")
>
> samp = function(N,sig,w,B){ .... [TRUNCATED]

> meanEst = function(variable,N,n,alpha){
+   m = c(sum(variable[which(results .... [TRUNCATED]
>
> N = c(1145,416)
> #total population of 1111 and 1113 respectively
> sig = c(17.23386,11.79957)
> #found through pilot study
> B = 0.5
> #arbitrary
>
> # Neyman allocation calculations:
> a=1145*sqrt(sig[1]) + 416*sqrt(sig[2])
> 1145*sqrt(sig[1]) / a
[1] 0.7688593
> 416*sqrt(sig[2]) / a
[1] 0.2311407
> #this a value was just used to calculate the w array
>
> w = c(0.7688593,0.2311407)
>
> n = ceiling(samp(N,sig,w,B)*w)
> #creates array of sample size for each stratum, while rounding the results up
> n
[1] 161  49

> n[1]/N[1] > 0.05
[1] TRUE
> #fpc is worth considering (returned true)
>
 .... [TRUNCATED]
[1] TRUE

> #fpc check for 1113 sample
> #fpc is worth considering
>
>
> colnames(results)

> #to test for ratio/regression estimators: review_session, test_ .... [TRUNCATED]

> #no linear correlation
> plot(results$review_session,results$MAC)

> #no linear correlation
```

```
> plot(results$review_session,results$past_hwquiz)

> #no linear correlation
>
> plot(results$test_review,results$MAC)

> #no linear correlation
> plot(results$test_review,results$past_hwquiz)

> #no linear correlation
>
> plot(results$MAC,results$past_hwquiz)

> #no linear correlation
>
>
> #no need for ratio estimators or regression estimators
>
> meanEst(results$review_session,N,n,0.05)
[[1]]
[1] 0.9526467
[[2]]
[1] 0.01628691
[[3]]
[1] 0.7025157 1.2027776
> meanEst(results$test_review,N,n,0.05)
[[1]]
[1] 2.849953
[[2]]
[1] 0.04782106
[[3]]
[1] 2.421347 3.278558
> meanEst(results$MAC,N,n,0.05)
[[1]]
[1] 0.1845847
[[2]]
[1] 0.003506988
[[3]]
[1] 0.06851593 0.30065339
> meanEst(results$past_hwquiz,N,n,0.05)
[[1]]
[1] 2.099463
[[2]]
[1] 0.03207153
[[3]]
[1] 1.748463 2.450464
> meanEst(results$other,N,n,0.05)
[[1]]
[1] 0.9259989
[[2]]
[1] 0.01799834
[[3]]
[1] 0.6630543 1.1889435
> meanEst(results$total,N,n,0.05)
[[1]]
[1] 7.012646
[[2]]
```

```
[1] 0.1627187
[[3]]
[1] 6.222028 7.803265
>
> pMaybe = N[1]/sum(N) * length(which(results$helpful.normalized. == 'maybe' & results$Class
== 1))/n[1] +
+          N[2]/sum(N) * length(which(resul .... [TRUNCATED]
> pNo =   N[1]/sum(N) * length(which(results$helpful.normalized. == 'no' & results$Class ==
1))/n[1] +
+         N[2]/sum(N) * length(which(results$he .... [TRUNCATED]
> varYes = (N[1]/sum(N))^2 * (pYes * (1-pYes)/(n[1]-1)) * (1-(n[1]/N[1])) +
+          (N[2]/sum(N))^2 * (pYes * (1-pYes)/(n[2]-1)) * (1-(n[2]/N[2]))
> varMaybe = (N[1]/sum(N))^2 * (pMaybe * (1-pMaybe)/(n[1]-1)) * (1-(n[1]/N[1])) +
+            (N[2]/sum(N))^2 * (pMaybe * (1-pMaybe)/(n[2]-1)) * (1- .... [TRUNCATED]
> varNo = (N[1]/sum(N))^2 * (pNo * (1-pNo)/(n[1]-1)) * (1-(n[1]/N[1])) +
+         (N[2]/sum(N))^2 * (pNo * (1-pNo)/(n[2]-1)) * (1-(n[2]/N[2]))
> CIYes = c(pYes - qnorm(1-0.05/2)*sqrt(varYes), pYes + qnorm(1-0.05/2)*sqrt(varYes))
> CIMaybe = c(pMaybe - qnorm(1-0.05/2)*sqrt(varMaybe), pMaybe +
qnorm(1-0.05/2)*sqrt(varMaybe))
> CINo = c(pNo - qnorm(1-0.05/2)*sqrt(varNo), pNo + qnorm(1-0.05/2)*sqrt(varNo))
> pYes
[1] 0.8151367
> varYes
[1] 0.001536437
> CIYes
[1] 0.7383111 0.8919622
> pMaybe
[1] 0.1627231
> varMaybe
[1] 0.001389158
> CIMaybe
[1] 0.08967247 0.23577373
> pNo
[1] 0.153867
> varNo
[1] 0.001327448
> CINo
[1] 0.08245735 0.22527664

> M = 303
> m[1]/M > 0.05
[1] TRUE

> #fpc worth considering for 1111 students in 0999
> m[2]/(N[1]-M) > 0.05
[1] FALSE
> #fpc not worth considering for 1111 students not in 0999
>
> qYes = length(which(results$MATH.0999 == 1 & results$helpful.normalized. == 'yes ....
[TRUNCATED]
> qMaybe = length(which(results$MATH.0999 == 1 & results$helpful.normalized. == 'maybe'))/m[1]
> qNo = length(which(results$MATH.0999 == 1 & results$helpful.normalized. == 'no'))/m[1]
> rYes = length(which(results$MATH.0999 == 0 & results$helpful.normalized. == 'yes' &
results$Class == 1))/m[2]
> rMaybe = length(which(results$MATH.0999 == 0 & results$helpful.normalized. == 'maybe' &
results$Class == 1))/m[2]
```

```
> rNo = length(which(results$MATH.0999 == 0 & results$helpful.normalized. == 'no' &
results$Class == 1))/m[2]
> varYesA = (qYes * (1-qYes)/(m[1]-1)) * (1-(m[1]/M))
> varMaybeA = (qMaybe * (1-qMaybe)/(m[1]-1)) * (1-(m[1]/M))
> varNoA = (qNo * (1-qNo)/(m[1]-1)) * (1-(m[1]/M))
> varYesB = (rYes * (1-rYes)/(m[2]-1))
> varMaybeB = (qMaybe * (1-qMaybe)/(m[2]-1))
> varNoB = (qNo * (1-qNo)/(m[2]-1))
> CIYesA = c(qYes - qnorm(1-0.05/2)*sqrt(varYesA), qYes + qnorm(1-0.05/2)*sqrt(varYesA))
> CIMaybeA = c(qMaybe - qnorm(1-0.05/2)*sqrt(varMaybeA), qMaybe +
qnorm(1-0.05/2)*sqrt(varMaybeA))
> CINoA = c(qNo - qnorm(1-0.05/2)*sqrt(varNoA), qNo + qnorm(1-0.05/2)*sqrt(varNoA))
> CIYesB = c(rYes - qnorm(1-0.05/2)*sqrt(varYesB), rYes + qnorm(1-0.05/2)*sqrt(varYesB))
> CIMaybeB = c(rMaybe - qnorm(1-0.05/2)*sqrt(varMaybeB), rMaybe +
qnorm(1-0.05/2)*sqrt(varMaybeB))
> CINoB = c(rNo - qnorm(1-0.05/2)*sqrt(varNoB), rNo + qnorm(1-0.05/2)*sqrt(varNoB))
> #q's are 0999, r's are not 0999
> #A's are 0999, r's are not 0999
>
> qYes
[1] 0.8148148
> varYesA
[1] 0.005286379
> CIYesA
[1] 0.6723108 0.9573189
> qMaybe
[1] 0.07407407
> varMaybeA
[1] 0.002402899
> CIMaybeA
[1] -0.02200214  0.17015029
> qNo
[1] 0.1111111
> varNoA
[1] 0.003460175
> CINoA
[1] -0.004180346  0.226402568
> rYes
[1] 0.6578947
> varYesB
[1] 0.006082953
> CIYesB
[1] 0.5050307 0.8107588
> rMaybe
[1] 0.2105263
> varMaybeB
[1] 0.001853706
> CIMaybeB
[1] 0.1261407 0.2949119
> rNo
[1] 0.1315789
> varNoB
[1] 0.002669336
> CINoB
[1] 0.0303162 0.2328417
> #again, most found MILE useful in both groups, but for not in 0999, appears to have larger
estimates for 'no'
```

```
> p1 = (qYes*m[1] + rYes*m[2])/(sum .... [TRUNCATED]
> p2 = (qMaybe*m[1] + rMaybe*m[2])/(sum(m))
> p3 = (qNo*m[1] + rNo*m[2])/(sum(m))
>
> z1 = (qYes - rYes)/(sqrt(p1 * (1-p1) * ((1/m[1]) + .... [TRUNCATED]
> z2 = (qMaybe - rMaybe)/(sqrt(p2 * (1-p2) * ((1/m[1]) + (1/m[2]))))
> z3 = (qNo - rNo)/(sqrt(p3 * (1-p3) * ((1/m[1]) + (1/m[2]))))
>
> 2*pnorm(-abs(z1))
[1] 0.1635494
> 2*pnorm(-abs(z2))
[1] 0.1329545
> 2*pnorm(-abs(z3))
[1] 0.8045016
> #no evidence that differences are found between 0999 and 1111 students' satisfactions with
MILE
```

References

Sampling Techniques, by William G. Cochran. Third edition, John Wiley & Sons, Inc. 1977