Statistics about social media use and sleeping quality among University of Toronto undergraduate students

STA304 - Fall 2023 -Assignment 1

Wai Yu Amanda Ng - 1008217350

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Part 1: Designing a survey

1.1 Goal

The sleep epidemic has been critiqued as a common and severe health problem among adults in modern days. Insufficient sleep causes significant negative impacts on both physical, mental and social health status. These consequences range from increased likelihood of accidents to adverse performance at school or workplace [1]. Insufficient quantity of sleep is defined as less than seven hours of sleep per night [2]. University students are especially vulnerable to the sleep epidemic [3] and a majority of university students reported occasional sleep problems [4]. While the use of social media networks can act as an entertainment tool and stress reliever for university students who suffer from academic pressure, some students may opt to sacrifice their sleep time in order to participate actively in social media networks. Multiple studies have concluded that higher rates of social media use contribute to greater sleep disturbance [5] and obsessive text checking contributes to lower quality sleep [6]. In this project, we aim to understand sleeping quality specifically among University of Toronto (UofT) undergraduate students and investigate the relationship between their social media network use patterns and sleeping quality. Our survey questions are designed to incorporate both objective data, including quantitative patterns of social media usage (amount of time and frequent use timeslots), sleeping-related data (amount of sleep, sleep latency), and subjective opinions towards their sleep quality. By analyzing the data obtained from the survey sample, we will be able to provide statistics on topics such as students' average sleep time, the most popular timeslot to use social media and differences in sleeping quality between students with different social media use patterns.

1.2 Procedure

Procedural outlines of collecting data

Based on the interest of our study, the target population is all UofT undergraduate students. To implement the survey on this population efficiently, STA304 students from both lecture sections form the frame population and will be invited to participate in this study. An announcement about the initiation and objectives of this study will be announced on the discussion board of the STA304 QUERCUS page, students will be encouraged to keep a record of their daily use pattern of social media networks and their sleep quality data (sleep time, number of wake ups during sleep etc) for a week. The Microsoft form survey link will then be provided the following week during the in-person STA304 class. Students will then input their responses during class and can raise any questions about the survey in case there is ambiguity. The sample population, hence, is UofT STA304 students who attend in-person lectures and return their responses through the form. Note that the whole process will take place during non-midterm and non-reading-week seasons since students tend to be more stressed and perhaps sleep less to study during mid-term seasons (vice versa during reading week), which creates biases in their sleep quality results.

Drawbacks

Since our sample only captures students who attend the in-person lectures and those who actually submit their responses during class, any results or conclusions drawn from data collected from this sample are subject to non-participation bias. Students who attend in-person lectures are usually more motivated or concerned about their learning, so they may spend less time on social media and devote more time to studying. Moreover, STA304 is a required course for Statistics Major and Specialist programs students. It is likely that the sample population comes from a relatively statistics-oriented background. Simply relying on data collected from statistics students potentially leave out students who are in the other study fields that may behave differently. For example, students doing Women and Gender Studies may use social media networks to get themselves exposed to and understand more about the current situation and recent news of gender equality through following protest information posts, blogs, etc. Meanwhile, students studying pure science (eg. Mathematics, Physics, etc) are less likely to need to use social media networks to gain knowledge in their fields. Hence, there may be significant social media use behaviour differences among students from different study fields. On top of that, the sample size from the STA304 student population (around 500 students) is relatively small compared to the target population (i.e. UofT undergraduate students) which has a size of more than 76 thousand [7]. Combined with the argument about students' main study field, this sample may be less representative of the target population.

Strengths

Firstly, collecting responses within the STA304 course is a time-efficient and cost-effective way. Forming a sample with the utilization of the course announcement function is an easier way to approach and invite participants. On the other hand, a convenience sample is not necessarily unfavourable. One of our study focuses involves students' self-ratings on their sleeping quality. As an STA304 student myself, using fellow STA304 students as the sample allows us to conduct follow-up studies after conducting the survey to understand respondents' subjective definition of sleep quality and opens up the possibility to further reflect on comments and data collected from the survey by re-approaching to the respondents. Additionally, the step of informing students about the survey one week before collecting their responses helps produce more reliable data for analysis. Interested participants are given sufficient time to note down the required information throughout the week instead of providing potentially false estimations right on the spot. Also, the in-person setting of data collection can ensure participants fully understand the survey questions and provide opportunities to clarify any ambiguity. Lastly, the non-mid-term season surveying feature ensures data are collected during normal school days when students receive a standard level of academic tasks and the results hence risk less bias.

1.3 Showcasing the survey

Link to survey: https://forms.office.com/r/h0zaYtxMaq.

Question 1: What is your average time spent on social media networks per day? (Please answer in minutes)

This question reflects the amount of time a university student spend on social media applications which is useful in understanding students' social media use habit. Besides, it is meaningful to consider the proportion social media accounts for in a university student's daily schedule and determine if such time portion is appropriate for university students in future research projects.

Pros: This question requires an answer correct to the nearest minute which improves the accuracy and precision of data collected. Time spent on social media is indicated on mobile devices' setting application that participants can check conveniently.

Cons: Participants have to take an extra step to record their social media use time every day. This potentially encourages participants to reflect on their social media use habits and change their usual daily use time to a "healthier" way during the one-week tracking period before the submission of their responses. Hence, the result (which is a daily average) may not truly reflect their original habit. This issue is hard to address since

we prioritize precision and the step of use time tracking relies solely on participants' actions. It is not ethical to forbid participants from reflecting on their habits and changing it if that is beneficial to them.

Question 2: When do you usually use social media networks during the course of a day?

Categorical options:

- Morning (from 6 am to 12 noon)
- Afternoon (from 12 noon to 6 pm)
- Evening (from 6 pm to 12 am)
- Late night (from 12 am to 6 am)

On top of observing how much time students spend on social media in a day, a main focus in students' social media use pattern involves observing which part of the day is the most popular social media use time-slot. This is done by categorizing 24 hours of a day into four same-length but distinct sections. Furthermore, we can compare the popular social media use time slot to students' sleep time. For example, we can look into the question "Do students use social media applications the most while they are supposed to be sleeping (i.e. late at night)?".

Pros: Instead of asking participants to put down the exact time frame they use social media the most, a rough estimation option is provided in this question design. Although precision is sacrificed in this design, it provides sufficient information to understand the general trend of choice of time to use social media among students.

Cons: The question is designed so that respondents can only choose one of the options. If respondents use social media evenly throughout the day or they spend an equal amount of time in more than one-time slot, they are forced to make a choice. Their results, hence, may not reflect the reality of their social media use habit. This issue is unavoidable since we would like to draw a conclusion on which part of the day has the highest social media use among students and we want to prevent students from choosing all options if they are unclear about their habit. We would like them to really reflect and provide only a single time slot as their response.

Question 3: How would you rate your sleeping quality? (Rate on a Likert scale from 0 to 10 with 0 being very bad, 5 being neutral and 10 being very good.)

There is no standard principle on what "good sleep" is. Hence, this question incorporates a subjective understanding of sleeping quality among students. Rather than determining respondents sleeping quality based simply on objective statistics (eg. hours of sleep, number of wake-ups during sleep) that may not be applicable to everyone, respondents can reflect on their past sleeps and determine their sleeping quality based on their own experience.

Pros: The Likert scale (consists of 11 options) allows respondents to stay neutral by choosing "5" if they do not think their sleeping quality is particularly good or bad, they are not forced to take a stance.

Cons: This question is subject to respondents' understanding of sleeping quality. The way each respondent defines "sleeping quality" may vary. For example, student A thinks simply having 7 hours of sleep (regardless of the number of wake-ups) equals good sleeping quality while student B thinks a 5-hour sleep without waking up in the middle means better sleeping quality than a 10-hour sleep with wake-ups in between. Therefore, the comparison of results between subjects may be challenging theoretically.

Part 2: Data Analysis

2.1 Data

Our sample consists of UofT STA304 students from both sections with a sample size of 500. Therefore, we generated a sample of size 500 through simple random sampling and the simulation seed is set to ensure consistency in data generated through random simulation in R.

For each question, we first store the possible responses in a option vector.

In question 1 (average daily time spent on social media), we assume the minimum minute spent is 0 minutes and the maximum is 250 minutes. So, the possible responses vector for Q1 is consists of all integers ranging from 0 to 250. 0 minutes is set as the minimum value to simulate students who do not use social media networks at all. 250 minutes is set as the maximum value using the following estimation:

- students attend lectures and focus on coursework for 9.5 hours
- students have 7.5 hours of sleep
- students spend 3 hours on other activities (eg. dining, leisure other than using social media networks, buffer time for extra sleep hours, etc)

The above activities accumulate for 20 hours, and students have at most 4 hours (which is around 250 minutes) remaining to spend on social media networks.

Similarly, in question 6 (sleeping quality rating), the Likert scale ranges from 0 to 10. So the possible responses vector for Q6 consists of integers from 0 to 10.

For questions 2 - 5, they all consist of categorical responses. We generate the possible responses vector in a similar manner as Q1 and Q6. However, we need to specify the names of categories this time since they are no longer integers. For example, question 2 is about the highest use of social media timeslot and has possible options of "Morning", "Afternoon", "Evening" and "Late night". So, the option vector should consists of the option strings as listed above. We do not pre-specify any probability assumption on the response proportion (i.e. all options of a question have an equal chance to be selected as the response) because we do not have sufficient information about the population behaviours and we want to avoid making implausible assumptions on the population while simulating a survey sample.

Then, all possible response vectors are saved under `variable_name` respectively. For example, Q1's possible responses vector is saved under the name `socialmedia_time` and Q2's possible responses vector is saved under the name `socialmedia_timeslot`.

Next, we simulate responses for each question. In this function, we plug in the possible responses vector, specify the sample size (i.e.500) and allows replacement of options to simulate the situation where multiple participants give identical responses. The random data generated by is saved under `variable_name_response`. For example, the Q1 simulated data vector is saved under the name `socialmedia_time_response`.

Lastly, we combine all questions' simulated data vectors into a data frame. The final data frame is saved under the name `our_data` which forms our data frame with 500 observations and 6 variables that store responses to the 6 survey questions respectively.

All 6 questions are set as mandatory in the survey link, therefore, no "not available" response should appear in the collected dataset and hence our simulated dataset. Hence, a cleaning process is not necessary at this stage.

2.11 Important variables

1. `socialmedia_time_spent_response`:

- It is an integer variable, from 0 to 360, indicating the average daily time spent on social media (correct to the nearest minute).

2. `socialmedia_timeslot_response`:

- It is a categorical variable, with possible results of "Morning", "Afternoon", "Evening", and "Late night", indicating the timeslot of which respondent uses social media the most.

3. `sleepingquality_response` :

- It is an integer rating variable, from 0 to 10, indicating respondents' self-rating on their sleeping quality in the past week.

2.12 Summary measures

Table 1: Statistics about STA304 students survey sample

Mean time spent on social media per day (in minutes)	Standard deviation of time spent on social media per day	Mean sleeping quality rating	Standard deviation of sleeping quality rating
126.91	71.48694	5.304	3.155233

The overall mean time spent on social media per day among all 500 STA304 students is 126.91 minutes and the overall mean sleeping quality rating is 5.304 minutes.

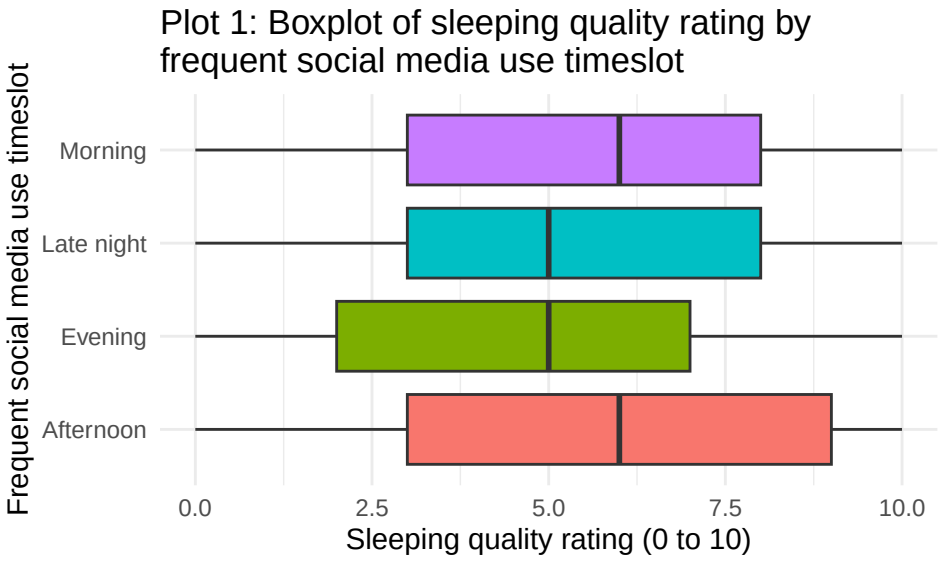
Table 2: Statistics about STA304 students survey sample grouped by frequent social media use timeslot

Frequnt social media use timeslot	Number of STA304 students	Mean time spent on social media per day (in minutes)	Mean sleeping quality rating
Afternoon	125	118.3440	5.576000
Evening	116	125.5086	4.551724
Late night	133	131.6090	5.496241
Morning	126	131.7381	5.523809

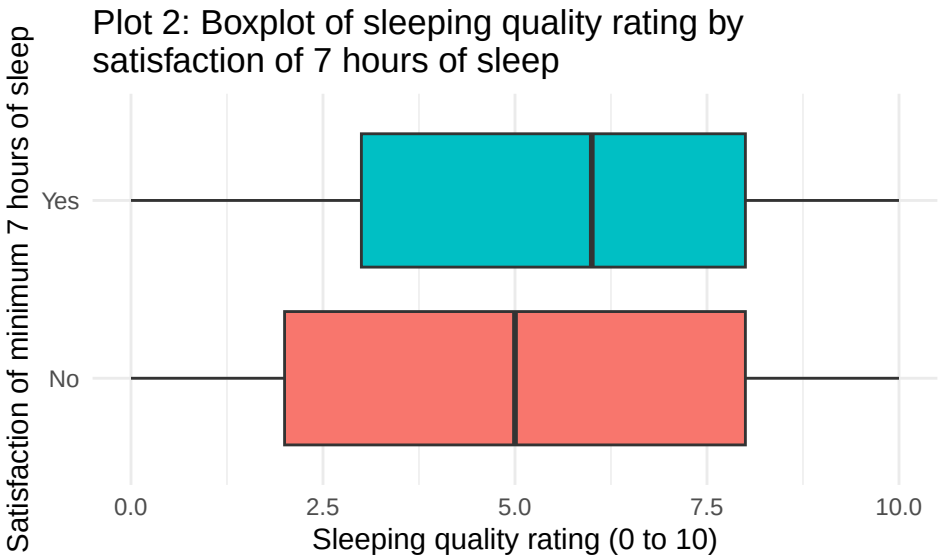
There are 126 students who use social media the most in the morning (6 am-12 noon), 125 students who use social media the most in the afternoon (12 noon-6 pm, 116 students who use social media the most in the evening (6 pm-12 am) and 133 students who use social media the most in late night (12 am-6 am). Late night is the timeslot where the highest number of students use their social media the most.

The mean time spent on social media per day for students grouped in the order of {morning, afternoon, evening, and late night} is 131.7, 118.3, 125.5, and 131.6 minutes respectively. The mean sleeping quality ratings are 5.52, 5.58, 4.55 and 5.50 respectively. Note that students from the afternoon group have the lowest mean social media time use and the highest mean sleeping quality rating.

2.13 Plots



The box plot above shows the distribution of sleeping quality ratings among students who use social media most in the same time slot. The black vertical lines inside the boxes indicate the median sleeping quality ratings of each group (with respect to the group that the box represents). It is obvious that the "Evening" and "Late night" groups (nighttime users) have significantly lower median sleeping quality ratings than those of the other two groups (daytime users).



The box plot above shows the distribution of sleeping quality ratings among groups of students who have/do not have at least 7 hours of sleep respectively. Similarly, the black vertical lines inside the boxes are the median sleeping quality ratings of each group (with respect to the group the box represents). As shown in the plot, students without at least 7 hours of sleep have a lower median and a lower 25% quartile sleeping quality rating than those with at least 7 hours of sleep.

According to our survey sample, the least selected time option to fall asleep is "Less than 30 minutes", of which 30.4% of respondents chose (refer to Barchart 1 and Table 3 available in the Appendix section) and the most selected number of wake ups during sleep per night is 0, of which 29.0% respondents chose (refer to Barchart 2 and Table 4 available in the Appendix section). This potentially reflects that students have a

hard time falling asleep but can generally sleep without waking up in the middle of the night.

All analysis for this report was programmed using `R version 4.0.2` [8], the above tables and plots are generated using `R knitr package` and `R Tidyverse package`[9].

2.2 Methods

2.21 Hypothesis test

We are interested in seeing if there is a relationship between sleeping quality ratings and frequently used social media time slots among UofT undergraduate students. As observed from the **Data section**, sleeping quality ratings mainly differ between Daytime users groups and Nighttime users groups. The hypothesis test is a statistical tool that helps draw conclusions about the true population parameter using sample data. Therefore, it is worth performing a hypothesis test [8] to see if there is a statistically significant difference in mean sleeping quality rating between daytime users and nighttime users among UofT undergraduate students.

In the following analysis, we will group respondents who indicated "Morning" or "Afternoon" as their most frequent social media use time-slot together as "Daytime" and respondents who responded "Evening" or "Late night" together as "Nighttime". The true population, defined as the pool of people who are drawn under for statistical study, is all UofT undergraduate students. The parameter, defined as the number describing the population, is the mean sleeping quality rating which is calculated by summing up all rating responses from the group and dividing it by group size.

Important parameters:

- μ_{day}: mean sleeping quality rating of UofT undergraduate students who mostly use social media during daytime (Morning and Afternoon)
- μ_{night}: mean sleeping quality rating of UofT undergraduate students who mostly use social media at night (Evening and Late night)
- μ_{day} - μ_{night}: difference in mean sleeping quality ratings between UofT undergraduate students who mostly use social media during daytime and UofT undergraduate students who mostly use social media at night.

Hypotheses:

Null hypothesis:

- The mean sleeping quality rating of those who mostly use social media during daytime (Morning and Afternoon) is the same as that of those who use social media at night (Evening and Late night).
- i.e. There is no difference in mean sleeping quality ratings between UofT undergraduate students who mostly use social media during daytime and those who mostly use social media at night.

$$H_0 : \mu_{day} - \mu_{night} = 0$$

Alternative hypothesis:

- The mean sleeping quality rating of those who mostly use social media during daytime (Morning and Afternoon) is different from that of those who use social media at night (Evening and Late night).
- i.e. There is a difference in mean sleeping quality ratings between UofT undergraduate students who mostly use social media during daytime and those who mostly use social media at night.

$$H_1 : \mu_{day} - \mu_{night} \neq 0$$

To determine if the null hypothesis is true, we will find the strength of evidence against the null hypothesis.

The test statistic used in this analysis is the difference in mean sleeping quality rating between STA304 students who mostly use social media during daytime (Morning and Afternoon) and STA304 students who use social media during nighttime (Evening and Late night). A simulated statistic is obtained by first generating

random samples of a size equivalent to our survey sample (i.e. 500) under the assumption that the null hypothesis H_0 holds true, then computing the random sample's parameter (μ_{day} - μ_{night}).

In this study, we simulate 1000 sets of random samples based on the H_0 assumption and generate a histogram by organizing the parameter of these 1000 sets of random samples into bars with width 0.05 starting from centring at 0, since H_0 assumes the difference to be 0. Next, we draw a vertical line with equation $x = test\ statistics$. We then measure the horizontal distance between the line to the peak of the histogram and draw another vertical line on the other side with the same distance to the peak. A P-value is obtained by counting the number of data on the histogram that are not enclosed in the two lines and dividing it by the number of simulated sets of data (1000). It represents the proportion of parameters from the samples which are at least as extreme as the test statistics. In general, if the p-value is larger than 0.05 (α level), there is a significant proportion of values that are at least as unusual as the test statistic. Hence, there is weak evidence against the null hypothesis. If the p-value is smaller than 0.05 (α level), there is sufficient evidence against the null hypothesis and the null hypothesis is likely to be false.

2.22 Bootstrapping and confidence interval

We are also interested in obtaining a mean value for time spent on social media networks per day among UofT undergraduate students. The true population, as established on the hypothesis test, is all UofT undergraduate students. The population parameter for this analysis is the mean time spent on social media networks per day, which is calculated by summing up the total time spent on social media networks per day by all students and then dividing it by the number of students. Although the mean time spent on social media networks per day of STA304 students from our survey sample can be calculated easily and is reported in the **Data section**. However, this single value most likely does not equal the mean value calculated from the true population.

So, we wish to produce a confidence interval that represents a range of plausible values for the true population parameter of interest (i.e. mean time spent on social media networks per day of UofT undergraduate students). A non-parametric bootstrap [8], a technique of statistical inference under the estimation branch, will be performed to compute the 95% confidence interval (CI) for the mean time spent on social media networks per day of UofT undergraduate students.

The bootstrap method starts with having access to a single representative sample from the population. An estimate is a statistic from a sample. Since we only have one sample data set of size 500, we can only obtain an estimate from it. In our analysis, we will assume this STA304 survey sample is a representative (i.e.not biased) sample of the UofT undergraduate student population. As mentioned above, this estimate may be close to, but probably does not equal the true population statistic. Hence, we will proceed to create an interval, the confidence interval, around the estimate which hopefully includes the true population statistic. We then produce many bootstrap samples of the same size as the original survey sample by randomly re-sampling (with replacement) from the original survey sample. In other words, observations from the original survey sample data are randomly selected with replacement to form new sample sets, namely the bootstrap samples. Note that bootstrapping never creates new data, all elements in the bootstrap sample are from our original survey sample. Therefore, many samples can be generated based on the original survey sample. We end the bootstrapping procedure by calculating the statistics from the original survey sample and estimates from each bootstrap sample.

Next, we will investigate the distribution of these statistics, namely bootstrap sampling distribution, by using percentiles. The pth percentile is the smallest value that is greater than or equal to the p% of all the values. For example, the 50th percentile equals to median. In general, a 95% confidence interval is believed to be able to include the true population parameter (as desired). A 95% CI is defined as: in 95% of possible samples by bootstrap resampling, their respective intervals will include the population parameter. The 95% confidence interval can be obtained by capturing the 97.5th percentile and 2.5th percentile. This allows us to get access to the middle part of the distribution and exclude the extreme outliers.

To conclude, bootstrapping is a method to reuse a single sample of data to produce more estimates. It helps produce a sufficient amount of estimates to generate an interval in which the true population parameter most likely lies. In this analysis, bootstrapping can produce a confidence interval which can highly likely capture the mean time spent on social media networks per day of UofT undergraduate students.

2.3 Results

The p-value of the hypothesis test with the null hypothesis "H_0: There is no difference in mean sleeping quality ratings between UofT undergraduate students who mostly use social media during daytime and those who mostly use social media at night." is 0.078 which is greater than 0.05 α level. (Histogram 1 shows the distribution of sleeping quality ratings difference generated from simulations and supports the calculation of p-value, it is available in the Appendix section.) Therefore, we do not have sufficiently strong evidence to reject the null hypothesis. As a result, we are unable to conclude that there are differences in mean sleeping quality ratings between UofT undergraduate students who mostly use social media during daytime and those who mostly use social media at night. This result is expected and reasonable since our original survey sample is randomly simulated without pre-specifying any probability to the response options. The sample data is simulated in a way that each sleeping quality rating option and time-slot options have an equal probability of being the observation response. Hence, there may not exist obvious differences in sleeping quality rating based on time-slot preferences.

The 95% confidence interval of mean time spent on social media networks per day of UofT undergraduate students (in minutes) is [120.3739, 133.314], which is an interval covering approximately 2-2.25 hours. (Histogram 2 shows the distribution of mean time spent on social media networks per day generated from bootstrapping and supports the calculation of confidence interval, it is available in the Appendix section.) We can conclude that [120.3739, 133.314] can highly likely capture the true mean time spent on social media networks per day (in minutes) of UofT undergraduate students. Since the confidence interval generated is subject to and depend highly on the quality of the sample data set that bootstrapping is performed, further studies are still required to validate the accuracy of this interval in describe the true population (all UofT undergraduate students).

Part 3: Referencing

3.1 Generative AI Statement

Generative artificial intelligence (AI) tools are not used in this study. These tools do not promise quality or accuracy in the information they provide. There are concerns about implausible content provided and violation of intellectual property (i.e. plagiarism) in these tools. Instead of merely copying information output from AI tools, I prefer incorporating knowledge taught in lectures and other credible sources such as textbooks and peer-reviewed academic journals and further provoking thoughts on the materials to develop critical thinking skills to finish assignments.

3.2 Bibliography

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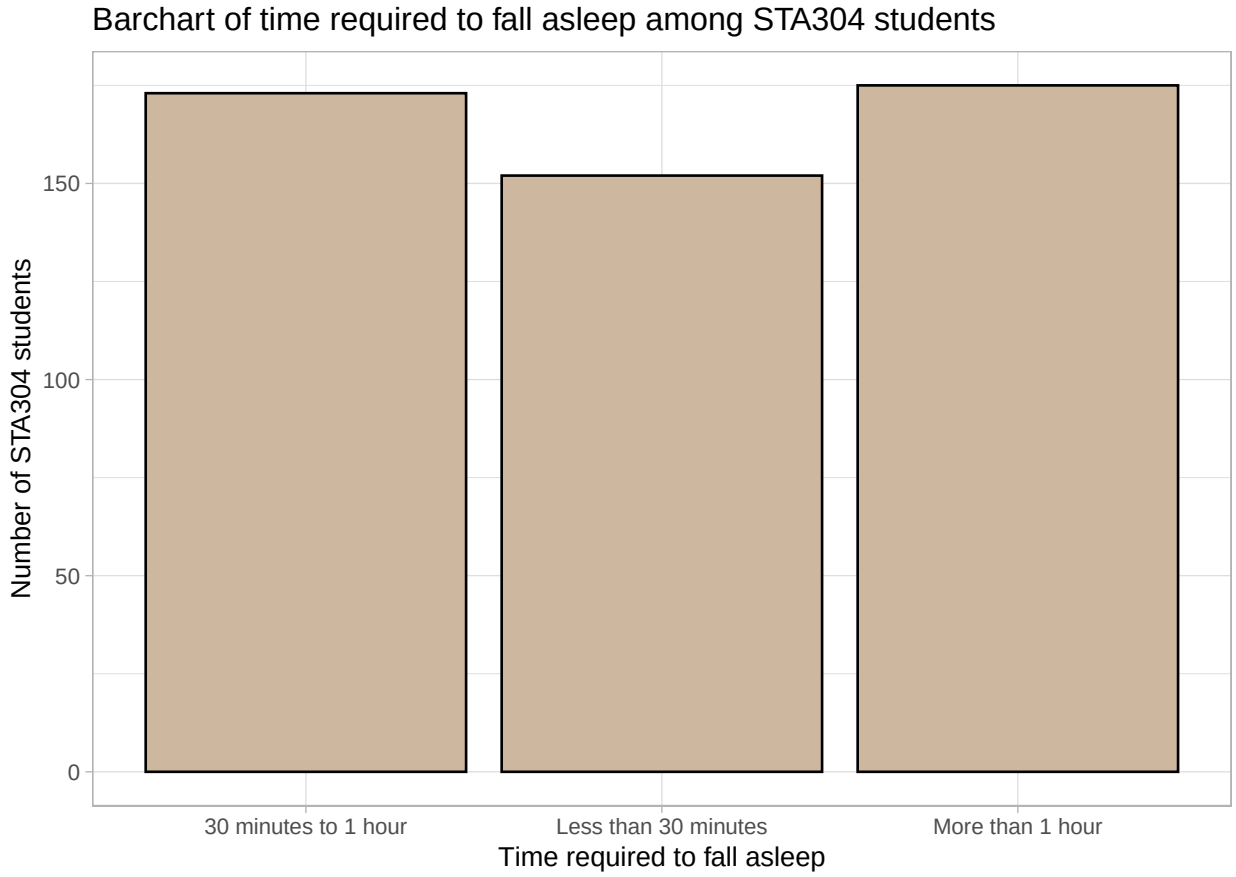
3.3 Appendix

Here is a glimpse of the data set simulated/surveyed:

```
## Rows: 500
## Columns: 6
## $ socialmedia_time_spent_response <int> 117, 14, 198, 82, 249, 73, 57, 127, 18~
## $ socialmedia_timeslot_response   <chr> "Evening", "Late night", "Late night",~
## $ sleephours_response             <chr> "No", "No", "No", "Yes", "No", "Yes", ~
## $ fallasleep_response             <chr> "More than 1 hour", "30 minutes to 1 h~
## $ wakeup_response                 <chr> "0", "3 or above", "3 or above", "0", ~
## $ sleepingquality_response        <int> 2, 3, 4, 3, 4, 3, 3, 2, 2, 6, 8, 2, 7,~
```

Below are some additional summary plots to support `Data` section:

Barchart 1



Barchart 2

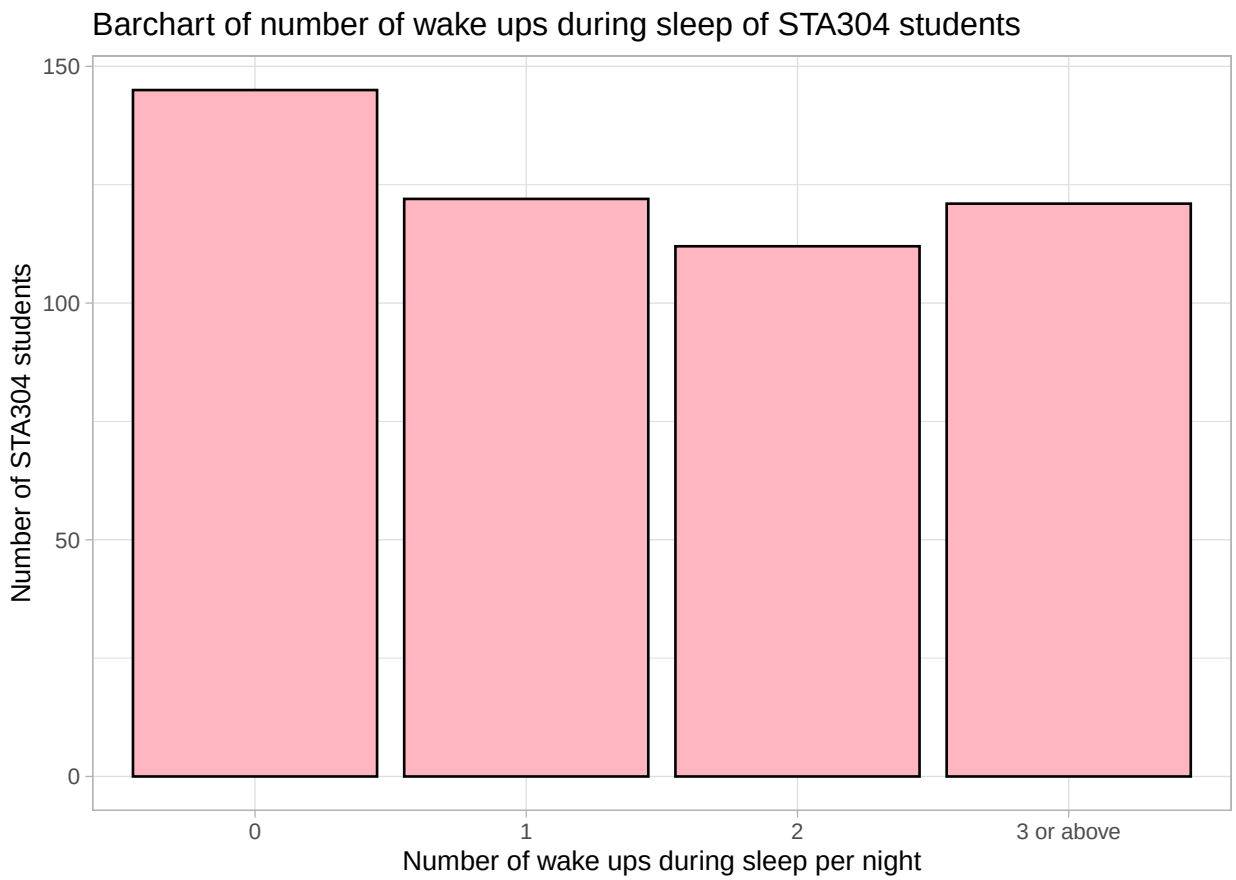


Table 3

Table 3: Summary table about time required to fall asleep among STA304 students

Time required to fall asleep	Percentage of STA304 students (%)
30 minutes to 1 hour	34.6
Less than 30 minutes	30.4
More than 1 hour	35.0

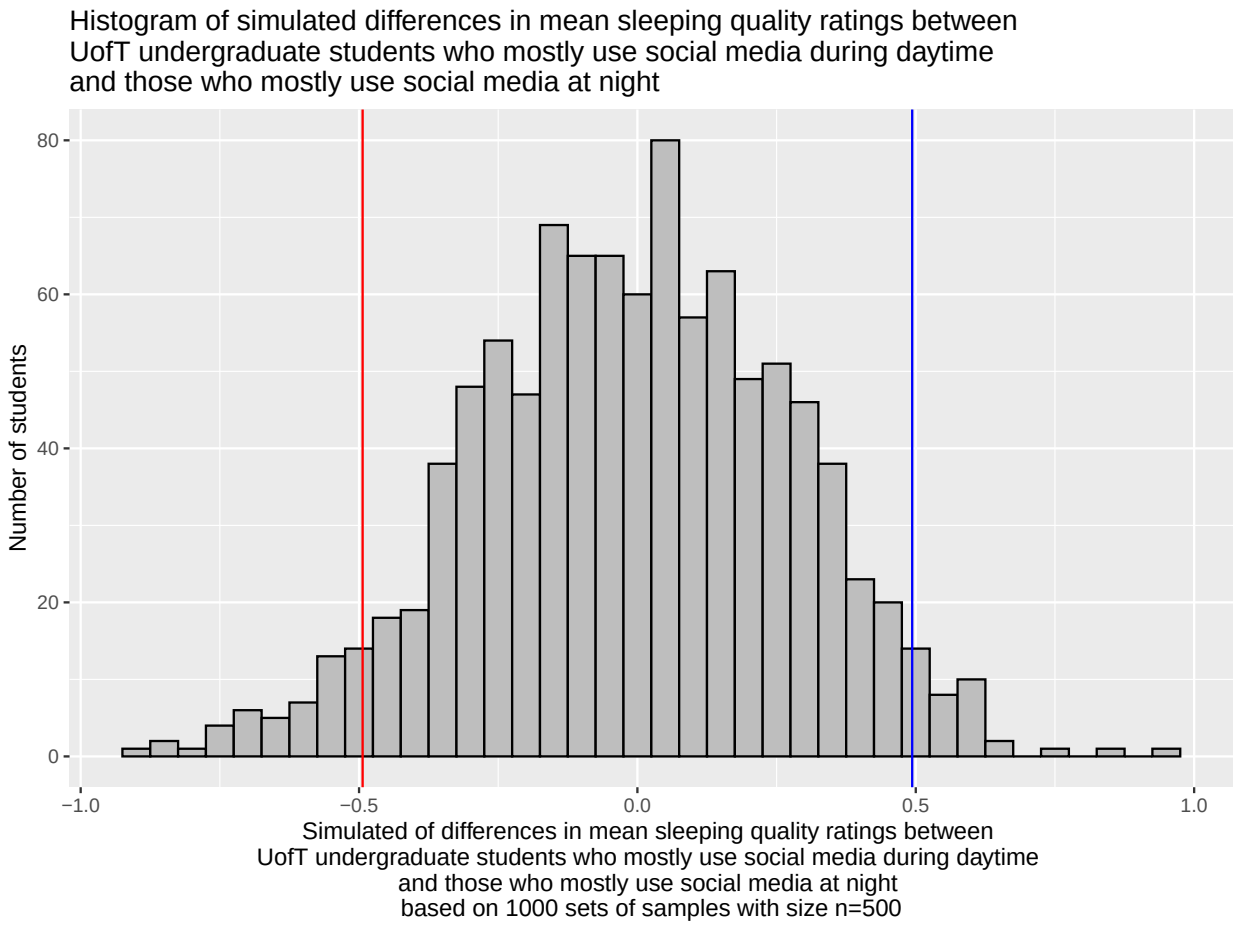
Table 4

Table 4: Summary table about wake ups during sleep of STA304 students

Number of wake ups during sleep per night	Percentage of STA304 students (%)
0	29.0
1	24.4
2	22.4
3 or above	24.2

Below is a histogram generated through the hypothesis test process:

Histogram 1



Below is a histogram generated through the bootstrapping process:

Histogram 2