STAT 344 Project

Sampling study on average number of capacity in UBC general teaching space

Group Members

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STAT 344

University of British Columbia

November 14, 2021

1 Introduction

Are learning spaces provided by The University of British Columbia (UBC) sufficient for classes to be engaging and interactive? In our sampling survey group project, we incorporate Simple Random Sampling (SRS) and Stratified Sampling to estimate our target parameters. Our information source was taken from a website provided by the University of British Columbia: Find A Learning Space.

1.1 Purpose of study

To evaluate UBC's statement, we believe the one most significant factor for collaborative and immersive learning environments is space capacity. With UBC's population of students and faculty sizes, it's significant that large spaces are available for students' use to discuss and interconnect without restrictions. Our sampling project is thus dedicated to assess this factor; whether or not UBC fulfills its promises to promote collaborative and dynamic learning with its space construction.

1.2 Objective

Our goal is to assess the ability of UBC Learning Spaces to promote engaging and interactive learning environments for UBC students. This strongly links to UBC's vision in Learning Space design as they strive to create collaborative, immersive, and dynamic learning spaces.

"The Learning Spaces team supports the creation, operation and maintenance of an excellent learning environment for students and faculty members."

Thus, the parameters we wish to estimate are:

- The average capacity of learning spaces listed on the **Find A Learning Space** website. *This is a continuous case to the study*
- The proportion of which the capacity of learning spaces is within the range of [30,100] students. *This is a binary case to the study.* We believe that class sizes that lie within this range offer intimate learning environments that aren't overwhelming and promote communication between students.

1.3 Background

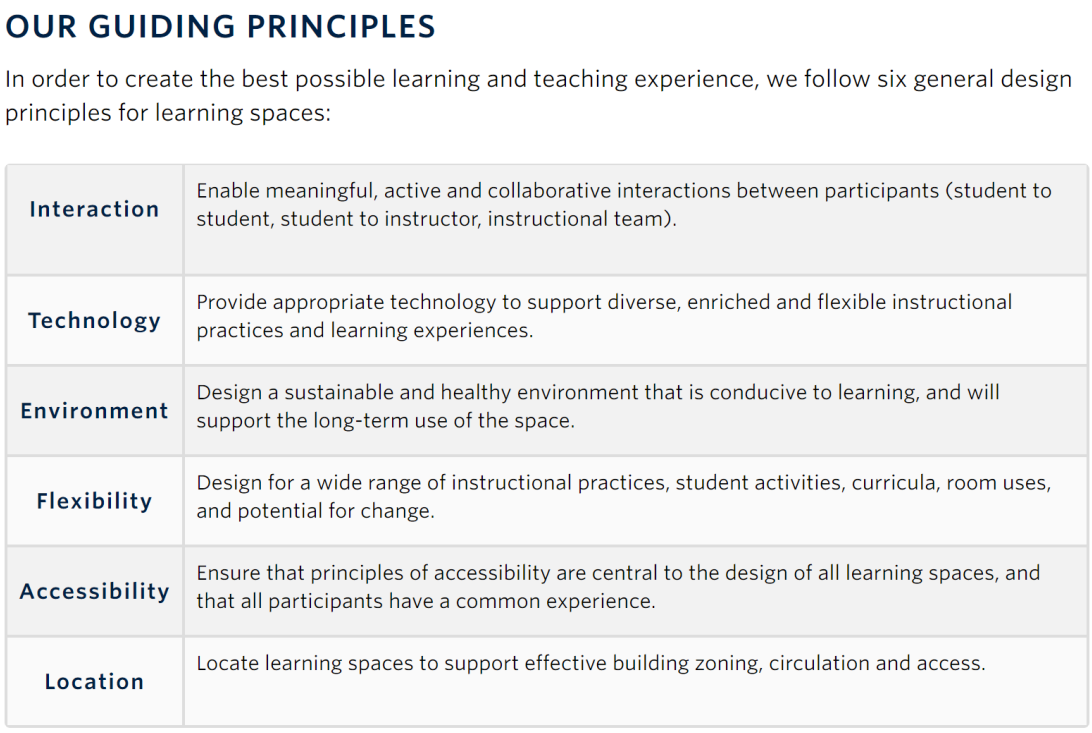
1.3.1 Defining Learning Space

From the **Find A Learning Space** website: UBC defines a "learning space" by the following:

"Learning at UBC doesn't just happen in classrooms, labs and other formal set-ups; it happens everywhere. This includes informal spaces, such as under a tree on a sunny day. Whether learning takes place in a quiet corner of the campus or a 500-seat lecture theatre, each and every learning space plays a crucial role in UBC's mission of teaching, learning, research, and engagement."

1.3.2 UBC's Learning Space Design Team Mission

The learning spaces provided by UBC are designed to support teaching learning that is accessible, immersive, collaborative, and technology-enriched.The following figure outlines UBC's Guiding Principles regarding Learning Space design:



OUR GUIDING PRINCIPLES

In order to create the best possible learning and teaching experience, we follow six general design principles for learning spaces:

Interaction	Enable meaningful, active and collaborative interactions between participants (student to student, student to instructor, instructional team).
Technology	Provide appropriate technology to support diverse, enriched and flexible instructional practices and learning experiences.
Environment	Design a sustainable and healthy environment that is conducive to learning, and will support the long-term use of the space.
Flexibility	Design for a wide range of instructional practices, student activities, curricula, room uses, and potential for change.
Accessibility	Ensure that principles of accessibility are central to the design of all learning spaces, and that all participants have a common experience.
Location	Locate learning spaces to support effective building zoning, circulation and access.

The number one principle is **Interaction**. Under this principle, much emphasis is placed on *collaboration*–enabling students' full potential in engagement.

2 Methodology

2.1 Data Collection and Preliminary study

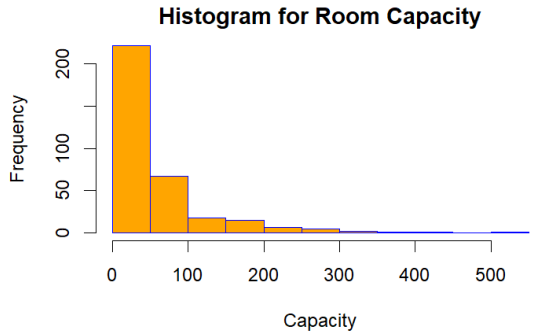
Our data collection comes from the website: Find A Learning Space. We decide to take all the learning spaces on the website as our population. By copying all the learning spaces info and importing them into R, we can find the parameter of our study:

- $\mu = 62.77$ is the mean of learning space capacity
- $\sigma = 68.42$ is the standard deviation

For our binary study (the proportion of learning spaces with capacity that $\geq$ 30 and $\leq$ 100, the parameters are:

- $p = 0.556$ is the population proportion
- $s_p = 0.497$ is the standard deviation of the population proportion

Since our population parameter is known, we will use these values as the preliminary study to determine our sample size
Below is a graph on the population distribution and population parameter



2.1.1 Strata

Our second sampling method will be stratified sampling. The first intuition is to use the "FURNITURE TYPE" column collected from the website. However, the within-stratum variation of the types are very large. So the furniture type becomes undesirable to be used as stratum.

Our second thought is to use the floor levels, since most large learning spaces are in the first or second floor. However, different buildings have different methods of numbering floors. Some, like Buchanan, have letters representing the sub-building the room is in. Some, like FNH, have room numbers with 2 digits as well as some with 3 digits. Some buildings have basements as the 0th floor while other buildings have basements as 1st floor. All of the above elements cause the within-stratum variation to be high.

Since none of the other features can be used as a reasonable stratum, we decide to introduce three types to categorize different learning spaces. We determine the type of each room with the help of the photos attached on the website. The three types of rooms are as follows:

1. We call the first type: Study Rooms. In our data, we label these as "1". We define study rooms by the following criteria:
    - All the chairs in the room must not face the same general direction
    - There can be at most one center that the chairs face together.
2. We call the second type: Classrooms. In our data, we label these as "1". We define class rooms by the following criteria: (it only needs to satisfy one of the following conditions)
    - All the chairs are facing one general direction and there are no height differences between rows
    - All the chairs are facing one general direction and there are less than 6 rows of chairs regardless of the height difference between rows
    - There are more than one tables that are centered by chairs
3. We call the third type: lecture halls. In our data, we label these as "1". We define lecture halls be the following single criteria:

(a) Study Room.

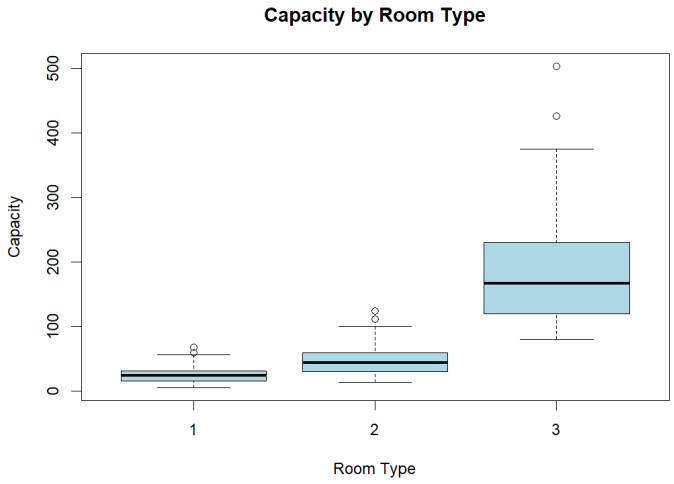
(b) Classroom.

(c) Lecture Hall.

Figure 1: Examples of different types of rooms.

- There are more than 5 rows of chairs, and there are height differences between rows

The three strata are reflective of our target parameter: the capacity of learning spaces. While have some overlap between the types. Here is a boxplot demonstrating the relationship between room types and capacity.



2.2 Sample Size Calculation

2.2.1 Simple Random Sample Size

We desire a 95% confidence interval with a width less than 0.15 for the proportion of rooms with $30 - 100$ capacity, and a 95% confidence interval with a width less than 20 for the average room capacity. Since the population size of 338 is known, taking Finite Population Correction (FPC) into consideration as $\frac{n}{N} > 0.05$, our sample size n* needs to satisfy:

$$n > (\frac{2 \times 1.96 \times s_{guess}}{width})^2$$

$$n* = \frac{n}{1 + \frac{n}{N}}$$

The results should be rounded up to the nearest integer above to meet the criteria. For binary case, we take the worst-case scenario $s_{guess} = \sqrt{0.5 \times (1 - 0.5)}$ and width of 95% confidence interval = 0.15, which gives the sample size n* = 114. For continuous case, based on the preliminary study, we take

$s_{guess} = s_p = 68.426$ and width of 95% confidence interval = 20, which gives the sample size n* = 118. In order to satisfy both of the criteria, we choose the larger value of n*, which is 118 for SRS method.

2.2.2 Stratified Sample Size

To calculate the strata samples sizes that minimize overall SE, we start from the SRS size and use the optimal allocation method:

$$\frac{n_h}{n} = \frac{N_h \times s_{h,guess}}{\sum_{k=1}^{H} N_k \times s_{k,guess}}$$

Please refer to section 4.1 for detailed stratified sample size calculation.

3 Method 1: Simple Random Sampling

After the sample size is calculated, the next step is to generate a simple random sample and calculate the sample mean and sample standard deviation. SRS method would allow us to estimate population mean and proportion by collecting the data of randomly sampled rooms, instead of collecting data for every single room in the population.

We use the function 'sample' in R to simulate the process of random sampling. We pass in the whole population as parameter and the sample size calculated in Section 2.2. All combinations of rooms with the total number of rooms equal to our desired sample size have equal chances to be randomly selected.

After getting the simple random sample, we calculate the sample mean and SE for continuous data and binary data, respectively. Then, we obtain the 95% confidence intervals. We take t = 1.96 as the population is large and can be approximated by the Normal distribution. FPC is applied as sample size of 118 is greater than 5% of the population size.

3.1 Continuous

The sample mean for continuous case is 66.9915, and standard error is calculated to be 4.7321 following the formula below. These lead to a 95% confidence interval of $[66.9915 - 1.96 \times 4.7321,\ 66.9915 + 1.96 \times 4.7321]$, which equals to [57.7165, 76.2665] for the average room capacity.

$$SE(\hat{\bar{y}}_{srs}) = \sqrt{(1 - \frac{n}{N}) \times \frac{s^2}{n}}$$

$$[\hat{\bar{y}}_{srs} - 1.96 \times SE,\ \hat{\bar{y}}_{srs} + 1.96 \times SE]$$

Therefore, we are 95% confident that true mean of capacity lies within [57.7165, 76.2665] if we were to repeatedly take simple random samples.

3.2 Binary

The sample proportion for binary case is 0.5932, and standard error is calculated to be 0.0365 following the formula below. We calculate the 95% confidence interval for the proportion of rooms with $30 - 100$

capacity to be $[0.5932 - 1.96 \times 0.0365,\ 0.5932 + 1.96 \times 0.0365]$, which is [0.5217, 0.6647].

$$SE(\hat{p}_{srs}) = \sqrt{(1 - \frac{n}{N}) \times \frac{\hat{p}(1-\hat{p})}{n}}$$
$$[\hat{p}_{srs} - 1.96 \times SE,\ \hat{p}_{srs} + 1.96 \times SE]$$

Therefore, we are 95% confident that true proportion of rooms with $30 - 100$ capacity lies within [0.5217, 0.6647] if we were to repeatedly take simple random samples.

4 Method 2: Stratified Sampling

We use stratified sampling as our second sampling method. For stratified sampling, we divide the whole population into several strata or groups. In each stratum, simple random sampling is applied. After combining the result of all strata, we can estimate the population features.We decide to use three strata based on the type of room in the learning space, please see section 2.1.1 for details.

4.1 Continuous

Table 1: Stratum Mean$_{Ph}$ & SD_{Ph}

	Study Room	Classroom	Lecture Hall
Mean	24.9912	47.7515	187.2364
SD	13.1287	20.9275	89.4390

For the continuous case, after obtaining the standard deviation of each stratum (rhsd), as shown in the Table 1 above, the next step is to determine the sample size of each stratum (shn) to minimize overall SE. We decide to use the general form of optimal allocation, without concerning the sampling cost (set cost as 1), which is:

$$\frac{n_h}{n} = \frac{N_h \times s_{h,guess}}{\sum_{k=1}^{H} N_k \times s_{k,guess}}$$

We define weight (shw) as $N_h \times s_{h,guess}$ (N_h: population size of each stratum, $s_{h,guess}$: guessed standard deviation of each stratum (rhsd), estimated by stratum population sd), and calculate the strata sample sizes (shn) based on the SRS size of 118 through $ceiling((s1w/sumw) \times 118)$. This leads the sample size of category 3 ('Lecture Hall') to be 59 and we constrain s3n to its stratum population size of 55. We then calculate the sample sizes of category 1 and 2 based on their optimal weight proportion. For example, sample size of category 1 is $s1n = ceiling((s1w/s3w) \times 55)$. We finally get the sample sizes of three strata - 17, 40, 55, respectively. Thus, the total sample size is 112.

Next, We use function 'sample' in R to get random sample from each stratum. With these samples, we can get sample stratified mean and sample stratified standard error to estimate the population mean and standard deviation, then, construct a 95% confidence interval. The formulas used are:

$$\hat{\bar{y}}_{str} = \sum_{h=1}^{H} \frac{N_h}{N} \times \hat{\bar{y}}_{Sh}$$

$$SE(\hat{\bar{y}}_{str}) = \sqrt{\sum_{h=1}^{H}(\frac{N_h}{N})^2 \times (1 - \frac{n_h}{N_h}) \times \frac{s_{Sh}^2}{n_h}}$$

$$[\hat{\bar{y}}_{str} - 1.96 \times SE,\ \hat{\bar{y}}_{str} + 1.96 \times SE]$$

The result shows sample stratified mean is 63.7936, sample stratified standard error is 2.0111, and we are 95% confident that true mean of capacity is within [59.8519, 67.7353] if we were to repeatedly take stratified samples.

4.2 Binary

Table 2: Stratum Proportion$_{Ph}$ & SD_{Ph}

	Study Room	Classroom	Lecture Hall
Proportion	0.3684	0.8225	0.1273
SD	0.4824	0.3821	0.3332

For the discrete (binary) case, we define p (rhp) as the proportion of rooms with $30-100$ capacity, and use $sd = \sqrt{p \times (1-p)}$ to get the standard deviation of each stratum (shpsd), as shown in the Table 2 above. Similar to the continuous case of stratified sampling above, we use optimal allocation and use the same definition of weight (shw) again. But this time, allocation is not constrained by the size of category 3. Instead, we use $ceiling((s1w/sumw) \times 118)$ to calculate sample sizes for three strata (shn). We finally get the sample size of three strata - 48, 56, 16, respectively. Thus, the total sample size is 120.

Again, after obtaining the random samples in R, we can get sample stratified proportion, sample stratified standard error and 95% confidence interval using the following formulas:

$$\hat{p}_{str} = \sum_{h=1}^{H} \frac{N_h}{N} \times \hat{p}_{Sh}$$

$$SE(\hat{p}_{str}) = \sqrt{\sum_{h=1}^{H}(\frac{N_h}{N})^2 \times (1 - \frac{n_h}{N_h}) \times \frac{\hat{p}_{Sh} \times (1 - \hat{p}_{Sh})}{n_h}}$$

$$[\hat{p}_{str} - 1.96 \times SE,\ \hat{p}_{str} + 1.96 \times SE]$$

The result shows sample stratified proportion is 0.5046, sample stratified standard error is 0.0307, and we are 95% confident that true proportion of rooms with $30-100$ capacity is within [0.4445, 0.5648] if we were to repeatedly take stratified samples.

5 Discussion

Reflecting on Sampling Methods

To answer our question for this project, we attempted to use the Simple Random Sampling and Stratified Sampling methods to estimate the population parameter:

- *Continuous case*: The average capacity of learning spaces listed on the **Find A Learning Space** website.
- *Binary case*: The proportion of which the capacity of learning spaces is within the range of [30,100] students.

Our results show that the stratified sampling method outperforms the simple random sampling method, in line with our intuition. We receive smaller standard errors for our estimates and thus narrower confidence intervals.

$$\frac{SE(\hat{\bar{y}}_{str})}{SE(\hat{\bar{y}}_{srs})}$$

,

$$\frac{SE(\hat{p}_{str})}{SE(\hat{p}_{srs})}$$

- For the continuous case to the study, the confidence interval under stratified sampling provides roughly a 57.7023% reduction in width.
- As for the binary case, the stratified sampling method provides roughly a 15.86% reduction in confidence interval width.

Table 3: Continuous Case

Type	Mean	SE	Confidence Interval
SRS	66.9915	4.7321	[57.7165, 76.2665]
Stratified	63.7936	2.0111	[59.8519, 67.7353]

Table 4: Binary Case

Type	Mean	SE	Confidence Interval
SRS	0.5932	0.0365	[0.5217, 0.6647]
Stratified	0.5046	0.0307	[0.4445, 0.5648]

6 Limitations

The most significant limitation to our sampling survey is that the 'Learning Spaces' website does not include all the rooms that are readily available for students to utilize as learning spaces. This is a matter of classification and definition in the schools' perspective in contrast to students'. Realistically, UBC students likely identify learning spaces as any place with tables and chairs, rooms inside any library or building, etc; much broader in a sense that would result in a bigger count of 'learning spaces.' Additionally, as UBC has been and is continuously developing new buildings and environments for the campus, it is highly possible that the website is simply outdated. The primary questions that can

be posed to UBC Learning Spaces admin are: What are the rubrics for categorizing learning spaces? What is the reason for leaving out other study spaces that deem reasonable to be categorized as one too?

Due to time and efficiency constraint, our group was not able to first-hand sample the entire university ground. If permissible, future research can implement census into its sampling method, receive the parameter values, simulate based on simple random sampling and stratified sampling techniques, then evaluate the accuracy of their estimates. However, the primary issue goes back to how a 'learning space' is defined, which can vary depending on the researchers' intentions.

7 Conclusion

Based off of the continuous and binary case from each sampling technique, the results suggest that roughly half of the UBC learning spaces satisfy our definition to be *interactive and engaging* for UBC students. We pre-defined *interactive and engaging* learning spaces to have capacity lie within the range [30, 100] students. The results are stored in Table 3 and Table 4, where the overlap of the two sampling methods' 95% confidence intervals in the continuous case is [58, 67]. This indicates that we expect the true average capacity of learning spaces at UBC to lie within this interval 95% of the time for repeated random samples. As for the binary case, the the overlap of the 95% confidence intervals is [0.52, 0.57], meaning that we are 95% confident that the true proportion of UBC learning spaces that can fit between 30 to 100 students is around half, 50% over repeated random samples.

We consider the results to be mediocre as only approximately half of the students satisfy our requirements. We believe that for future designs of learning spaces, UBC should consider these factors to establish better, more interactive, and engaging environments for UBC students.

8 Appendix

2.2 PRINCIPLES FOR LEARNING SPACE DESIGN

1. Interaction

Enable meaningful, active and collaborative interactions between participants (student to student, student to instructor, instructional team).

a. Furniture supports collaboration and group work.

b. Participants can move around the room easily and instructional processes can occur anywhere in the room.

c. Appropriate acoustics for a wide range of activities so that all participants can effectively hear each other.

d. Table and wall surfaces support student work (e.g. multiple marker boards, projection surfaces/video displays, maker equipment).

***Design checklist questions*:**

☐ *Will the space layout and circulation support **instructor movement** throughout the space, and provide the instructor with opportunities to make easy eye contact with students?*

☐ *Will the space layout and furniture promote **collaborative, discussion based student work** with appropriate discussion aids?*

STAT344 Final Project

28/09/2021

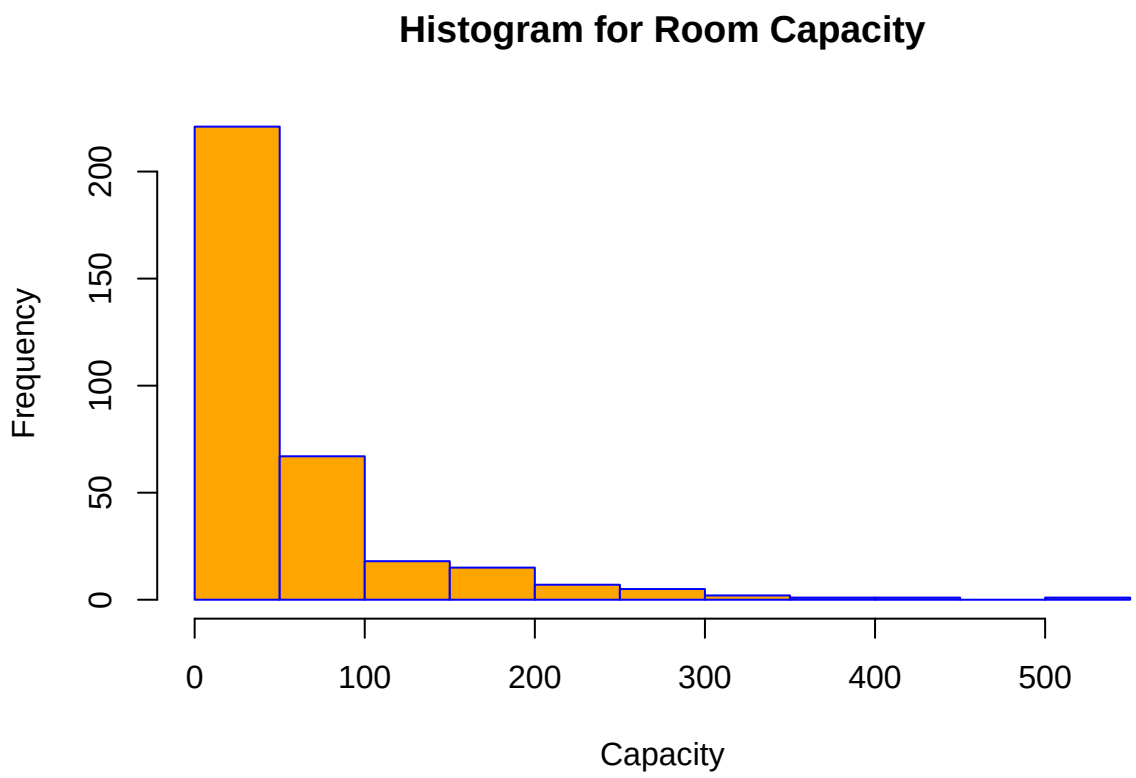
Preliminary Study:

The parameter values from our school website provides that the:

- The mean learning space capacity $\mu = 62.77$
- The standard deviation $\sigma = 68.325$
- True proportion of learning spaces > 140 in capacity $p = 0.1094675$

Histogram

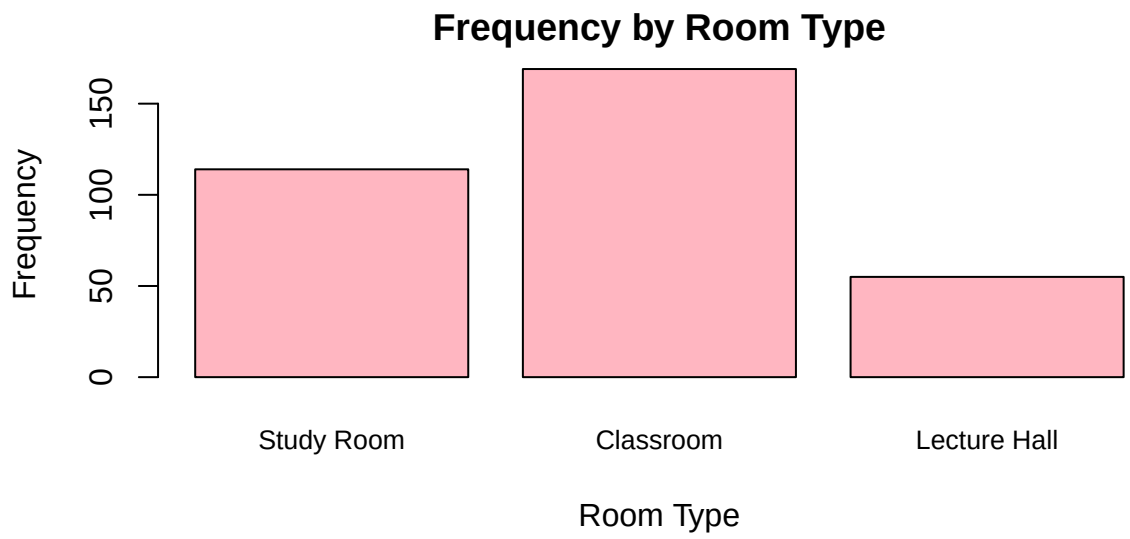
```
names = c("Study Room","Classroom","Lecture Hall")
hist(Rooms$CAPACITY,main="Histogram for Room Capacity",xlab="Capacity",col="orange",border = "blue")
```



```
counts = table(Rooms$Room.type)
counts
```

```
##
##   1   2   3
## 114 169  55
```

```
par(mar = c(12, 4, 2, 2) + 0.2)
barplot(counts,xlab="Room Type", ylab = "Frequency" ,main = "Frequency by Room Type",names.arg=names, c
```




```
# Continuous Case
mean(Rooms$CAPACITY)
```

```
## [1] 62.77219
```

```
sd(Rooms$CAPACITY) # 68.426
```

```
## [1] 68.42647
```

```
# Binary Case
sum((Rooms$CAPACITY>=30 & Rooms$CAPACITY<=100)/338) #0.556213
```

```
## [1] 0.556213
```

```r
sqrt((0.556213)*(1-0.556213)) # 0.4968301
```

```
## [1] 0.4968301
```

We want the width of our confidence interval in estimating average capacity size of UBC learning spaces to be less than 20. Thus: $2 \times 1.96 \times \sqrt{(1 - \frac{n}{338}) \times \frac{68.426^2}{n}} < 20$. which gives an sample size of $n = 118$.

As for the discrete case, we look at the proportion of learning spaces with capacity larger than 140 students. We take the worst case scenario for $\hat{p} = 0.5$

Thus, $s^2_{guess} = 0.5(1 - 0.5) = 0.25$ To receive results within ± 0.05, we solve for: $0.05 = 1.96 \times \sqrt{(1 - \frac{n}{338}) \times \frac{0.5^2}{n}}$ which gives $n = 180$

SRS Sampling

```
set.seed(12345)
srs <- sample(1:338, 118, replace = FALSE)
sort(srs)
```

```
##   [1]   3   5   7   8  12  13  14  16  18  23  25  30  31  32  34  36  38  40
##  [19]  42  46  51  55  56  58  60  62  67  68  74  75  76  78  80  86  90  91
##  [37]  92  93  95  98  99 100 103 106 109 111 116 120 123 124 132 134 135 137
##  [55] 140 141 142 145 146 148 152 153 154 156 163 165 166 176 178 187 192 197
##  [73] 202 208 211 212 214 216 218 220 221 223 229 232 234 245 246 248 249 252
##  [91] 254 255 257 258 259 262 266 267 270 278 280 281 283 284 286 288 289 294
## [109] 297 298 299 302 304 311 312 314 330 334
```

```
sample<-Rooms$CAPACITY[srs]
sample
```

```
##   [1]  60 190  40  40  60  32   6  65  68  34  22  30  24  80 114  30 294  24
##  [19]  50  30  40 265  30  90  42  48  25  80 114  44  41  30  54  32 225 120
##  [37]  20  25  58  40  30   8  25  44  20   8 240  30  60  20  94  78 100  88
##  [55]  72  63  40 295  42  40 250  25  16 236  40  78  30 150  35  22  18 150
##  [73] 183  21  27 120  40  60  26  40   8 240 120  30  48  32  20  65  32  40
##  [91]  24  75  50  30  54  64  80  22  65  32  30 154  14 100 100   8  24  72
## [109]  28  14  25  68  78  62 181  58  48  30
```

```
sort(sample) # Sample values for learning space capacity
```

```
##   [1]   6   8   8   8   8  14  14  16  18  20  20  20  20  21  22  22  22  24
##  [19]  24  24  24  25  25  25  25  25  26  27  28  30  30  30  30  30  30  30
##  [37]  30  30  30  30  30  32  32  32  32  32  34  35  40  40  40  40  40  40
##  [55]  40  40  40  40  41  42  42  44  44  48  48  48  50  50  54  54  58  58
##  [73]  60  60  60  60  62  63  64  65  65  65  68  68  72  72  75  78  78  78
##  [91]  80  80  80  88  90  94 100 100 100 114 114 120 120 120 150 150 154 181
## [109] 183 190 225 236 240 240 250 265 294 295
```

Continuous

```
cts_mean=mean(sample) # Continuous case, mean capacity for sample = 66.99
cts_se=sqrt(var(sample)/118 * (1-(118/N))) # 4.73

print(c(cts_mean,cts_se))
```

```
## [1] 66.991525  4.732145
```

95% Confidence Interval

```
lower_bound=cts_mean-1.96*cts_se

upper_bound=cts_mean+1.96*cts_se

print(c(lower_bound,upper_bound))
```

```
## [1] 57.71652 76.26653
```

Binary

```
prop<-(sum(sample>=30 & sample<=100)/118)
prop # 0.5932203
```

```
## [1] 0.5932203
```

```
se_prop<-(sqrt(prop*(1-prop)/118*(1-118/338)))
se_prop # 0.03648376
```

```
## [1] 0.03648376
```

95% Confidence Interval

```
lower_bound_bin=prop-1.96*se_prop

upper_bound_bin=prop+1.96*se_prop

print(c(lower_bound_bin,upper_bound_bin))
```

```
## [1] 0.5217122 0.6647285
```

Stratified Sampling

We will have our strats based on the type of room in the learning space. The possible types are the following: * Category 1: We define 'study rooms' to be * Category 2: 'Classroom' * Category 3: 'Lecture hall'

```
library(dplyr)
r1<-filter(Rooms,Room.type==1)
r2<-filter(Rooms,Room.type==2)
r3<-filter(Rooms,Room.type==3)

mean(r1$CAPACITY)
```

```
## [1] 24.99123
```

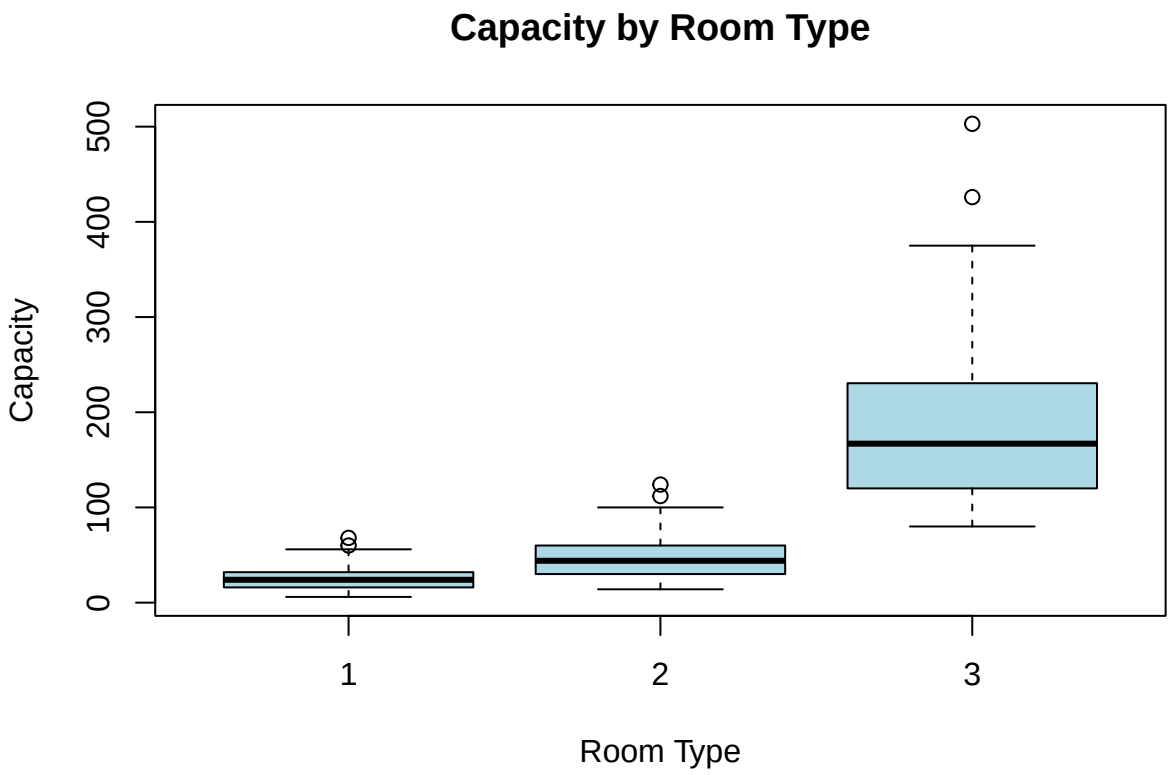
```
mean(r2$CAPACITY)
```

```
## [1] 47.75148
```

```
mean(r3$CAPACITY)
```

```
## [1] 187.2364
```

```
boxplot(CAPACITY~Room.type,data=Rooms,main="Capacity by Room Type",xlab= "Room Type", ylab = "Capacity"
```



We choose our sample size n to be approximately proportional to $N_h \times s_{h_guess}$

```r
# Calculate variability


r1sd=sd(r1$CAPACITY)
r2sd=sd(r2$CAPACITY)
r3sd=sd(r3$CAPACITY)

print(c(r1sd,r2sd,r3sd))
```

```
## [1] 13.12870 20.92753 89.43898
```

```r
# optimal allocation


# weight
  # constraint s3n = 55

s1w = nrow(r1)*r1sd
s2w = nrow(r2)*r2sd
s3w = nrow(r3)*r3sd


print(c(s1w,s2w,s3w))
```

```
## [1] 1496.672 3536.753 4919.144
```

```r
sumw=sum(s1w,s2w,s3w)
sumw
```

```
## [1] 9952.569
```

```r
s1n = (s1w/sumw)*118
s2n = (s2w/sumw)*118
s3n = (s3w/sumw)*118


print(c(s1n,s2n,s3n))
```

```
## [1] 17.74489 41.93258 58.32253
```

```r
  # constraint s3n = 55
s3n = 55
s1n = ceiling((55/s3w)*s1w)
s1n
```

```
## [1] 17
```

```r
s2n = ceiling((55/s3w)*s2w)
s2n
```

```
## [1] 40
```

```
s1W = nrow(r1)/N
s2W = nrow(r2)/N
s3W = nrow(r3)/N
```

- s1 (Study Rooms) n = 17
- s2 (Classroom) n = 40
- s3 (Lecture Hall) n = 55

total sample size = 112

```
# sampling
set.seed(200)

s1s<-sample_n(r1,size=17,replace=FALSE)
s2s<-sample_n(r2,size=40,replace=FALSE)
s3s<-sample_n(r3,size=55,replace=FALSE)


stratified_sample=rbind(s1s,s2s,s3s)
```

```
strata_mean = s1W*mean(s1s$CAPACITY) +
  s2W*mean(s2s$CAPACITY) +s3W*mean(s3s$CAPACITY)
# stratified mean = 63.79358

strata_se = sqrt(s1W^2*var(s1s$CAPACITY)/s1n * (1-(s1n/nrow(r1))) +
                   s2W^2 * var(s2s$CAPACITY)/s2n * (1-(s2n/nrow(r2))) +
                                                    s3W^2*var(s3s$CAPACITY)/s3n * (1-(s3n/nrow(r3))))

strata_mean
```

```
## [1] 63.79358
```

```
strata_se
```

```
## [1] 2.011052
```

```
# stratified estimate se = 2.011052
```

95% Confidence Interval

```
lb_strata=strata_mean-1.96*strata_se

ub_strata=strata_mean+1.96*strata_se

print(c(lb_strata,ub_strata))
```

```
## [1] 59.85192 67.73525
```

Width Ratio

```
# CONTINUOUS
strata_se/cts_se
```

```
## [1] 0.4249769
```

```
reduction_cts = (1-strata_se/cts_se)*100
reduction_cts
```

```
## [1] 57.50231
```

```
# roughly 57.50231% reduction
```

Stratified Binary

```
# Calculate variability
r1p<-(sum(r1$CAPACITY>=30 & r1$CAPACITY<=100)/nrow(r1)) # 0.368
r2p<-(sum(r2$CAPACITY>=30 & r2$CAPACITY<=100)/nrow(r2)) # 0.822
r3p<-(sum(r3$CAPACITY>=30 & r3$CAPACITY<=100)/nrow(r3)) # 0.127

print(c(r1p,r2p,r3p))
```

```
## [1] 0.3684211 0.8224852 0.1272727
```

```
r1psd<-(sqrt(r1p*(1-r1p))) # 0.482
r2psd<-(sqrt(r2p*(1-r2p))) # 0.382
r3psd<-(sqrt(r3p*(1-r3p))) # 0.333



print(c(r1psd,r2psd,r3psd))
```

```
## [1] 0.4823764 0.3821038 0.3332782
```

```
# optimal allocation


# weight

s1w = nrow(r1)*r1psd
s2w = nrow(r2)*r2psd
s3w = nrow(r3)*r3psd


print(c(s1w,s2w,s3w))
```

```
## [1] 54.99091 64.57554 18.33030
```

```
sumw=sum(s1w,s2w,s3w)
sumw
```

```
## [1] 137.8967
```

```
s1n = ceiling((s1w/sumw)*118)
s2n = ceiling((s2w/sumw)*118)
s3n = ceiling((s3w/sumw)*118)


print(c(s1n,s2n,s3n))
```

```
## [1] 48 56 16
```

```
# total n = 120
s1W = nrow(r1)/N
s2W = nrow(r2)/N
s3W = nrow(r3)/N
```

```
set.seed(200)

s1sb<-sample_n(r1,size=s1n,replace=FALSE)
s2sb<-sample_n(r2,size=s2n,replace=FALSE)
s3sb<-sample_n(r3,size=s3n,replace=FALSE)


stratified_sample_b=rbind(s1sb,s2sb,s3sb)
# binary
s1p<-(sum(s1sb$CAPACITY>=30 & s1sb$CAPACITY<=100)/nrow(s1sb)) # 0.368
s2p<-(sum(s2sb$CAPACITY>=30 & s2sb$CAPACITY<=100)/nrow(s2sb)) # 0.822
s3p<-(sum(s3sb$CAPACITY>=30 & s3sb$CAPACITY<=100)/nrow(s3sb)) # 0.127

strata_mean_b = s1W*s1p + s2W*s2p +s3W*s3p

# 0.5046
strata_se_b = sqrt(s1W^2*(s1p)*(1-s1p)/s1n * (1-(s1n/nrow(r1))) +
                   s2W^2 *(s2p)*(1-s2p)/s2n * (1-(s2n/nrow(r2))) +
                                                s3W^2*(s3p)*(1-s3p)/s3n* (1-(s3n/nrow(r3))))

# stratified estimate se = 0.0307

strata_se_b
```

```
## [1] 0.03069659
```

95% Confidence Interval

```
lb_strata_p=strata_mean_b-1.96*strata_se_b

ub_strata_p=strata_mean_b+1.96*strata_se_b
```

```r
print(c(lb_strata_p,ub_strata_p))
```

```
## [1] 0.4444575 0.5647881
```

Width Ratio

```r
# BINARY
strata_se_b/se_prop
```

```
## [1] 0.8413768
```

```r
reduction = (1-strata_se_b/se_prop)*100
reduction
```

```
## [1] 15.86232
```

```r
# roughly 15.86% reduction
```

CODE	ROOM #	BUILDING NAME	FURNITURE TYPE	CAPACITY	PHOTO	DETAILS	Room type
IRC	2	P.A. Woodward Instructional Resources	Fixed Tablets	503		INFO	3
CIRS	1250	Centre for Interactive Research on	Fixed Tablets	426		INFO	3
HEBB	100	Hebb	Fixed Tables	375		INFO	3
ESB	1013	Earth Sciences Building	Fixed Tablets	350		INFO	3
WESB	100	Wesbrook	Fixed Tablets	325		INFO	3
SCRF	100	Neville Scarfe	Fixed Tablets	295		INFO	3
LIFE	2201	UBC Life Building	Fixed Tables	294		INFO	3
BUCH	A101	Buchanan	Fixed Tablets	275		INFO	3
CHEM	B150	Chemistry	Fixed Tablets	265		INFO	3
ANGU	98	Henry Angus	Fixed Tables	260		INFO	3
FSC	1005	Forest Sciences Centre	Fixed Tablets	250		INFO	3
BIOL	1000	Biological Sciences	Fixed Tables	240		INFO	3
CHEM	B250	Chemistry	Fixed Tablets	240		INFO	3
PHRM	1101	Pharmaceutical Sciences Building	Fixed Tables	236		INFO	3
GEOG	100	Geography	Fixed Tablets	225		INFO	3
MATH	100	Mathematics	Fixed Tablets	224		INFO	3
LSK	200	Leonard S. Klinck	Fixed Tables	205		INFO	3
CHBE	101	Chemical and Biological Engineering	Fixed Tables	200		INFO	3
MCML	166	MacMillan	Fixed Tablets	200		INFO	3
SWNG	221	West Mall Swing Space	Fixed Tables	190		INFO	3
SWNG	222	West Mall Swing Space	Fixed Tables	190		INFO	3
SWNG	122	West Mall Swing Space	Fixed Tables	188		INFO	2
SWNG	121	West Mall Swing Space	Fixed Tables	187		INFO	3
LSK	201	Leonard S. Klinck	Fixed Tables	183		INFO	3
BUCH	A201	Buchanan	Fixed Tablets	181		INFO	2
IRC	6	P.A. Woodward Instructional Resources	Fixed Tablets	181		INFO	3
HENN	200	Hennings	Moveable Tables	180		INFO	3
PHRM	1201	Pharmaceutical Sciences Building	Fixed Tables	167		INFO	3
DMP	310	Hugh Dempster Pavilion	Fixed Tables	160		INFO	3
FRDM	153	Friedman Building	Fixed Tables	160		INFO	3
HENN	201	Hennings	Fixed Tablets	155		INFO	3
IBLC	182	Irving K Barber Learning Centre	Fixed Tables	154		INFO	3
BUCH	A102	Buchanan	Fixed Tablets	150		INFO	3
BUCH	A104	Buchanan	Fixed Tablets	150		INFO	3
ESB	1012	Earth Sciences Building	Fixed Tablets	150		INFO	3
HENN	202	Hennings	Fixed Tablets	150		INFO	3
AERL	120	Aquatic Ecosystems Research Laboratory	Fixed Tablets	144		INFO	3
BUCH	A103	Buchanan	Fixed Tablets	131		INFO	3
LIFE	2302	UBC Life Building	Fixed Tables	124		INFO	2
DMP	110	Hugh Dempster Pavilion	Fixed Tables	120		INFO	3
IRC	1	P.A. Woodward Instructional Resources	Fixed Tables	120		INFO	3
IRC	4	P.A. Woodward Instructional Resources	Fixed Tables	120		INFO	3
IRC	5	P.A. Woodward Instructional Resources	Fixed Tables	120		INFO	3
CHEM	D200	Chemistry	Fixed Tablets	114		INFO	2
CHEM	D300	Chemistry	Fixed Tablets	114		INFO	3
IBLC	261	Irving K Barber Learning Centre	Moveable Tables	112		INFO	2
BUCH	A202	Buchanan	Fixed Tables	108		INFO	3
BUCH	A203	Buchanan	Fixed Tables	108		INFO	3
MATX	1100	Mathematics Annex	Fixed Tablets	106		INFO	3
WESB	201	Wesbrook	Fixed Tablets	102		INFO	3
CEME	1202	Civil and Mechanical Engineering	Fixed Tables	100		INFO	2
GEOG	200	Geography	Fixed Tables	100		INFO	2
IONA	301	Iona Building	Fixed Tables	100		INFO	3
FNH	60	Food, Nutrition and Health	Fixed Tablets	99		INFO	2
FSC	1221	Forest Sciences Centre	Fixed Tablets	99		INFO	3
ALRD	105	Allard Hall	Fixed Tables	94		INFO	2
CHBE	102	Chemical and Biological Engineering	Fixed Tables	94		INFO	2
ANSO	207	Anthropology and Sociology	Moveable Tablets	90		INFO	2
CHEM	C124	Chemistry	Fixed Tablets	90		INFO	3

CHEM	C126	Chemistry	Fixed Tablets	90		INFO	3
LIFE	2202	UBC Life Building	Fixed Tables	90		INFO	2
IRC	3	P.A. Woodward Instructional Resources	Fixed Tables	88		INFO	3
DMP	301	Hugh Dempster Pavilion	Fixed Tables	80		INFO	2
ESB	2012	Earth Sciences Building	Fixed Tables	80		INFO	2
HEBB	114	Hebb	Moveable Tables	80		INFO	2
LASR	102	Frederic Lasserre	Fixed Tables	80		INFO	3
LASR	104	Frederic Lasserre	Fixed Tables	80		INFO	3
BUCH	B213	Buchanan	Fixed Tables	78		INFO	2
BUCH	B215	Buchanan	Fixed Tables	78		INFO	2
BUCH	B313	Buchanan	Fixed Tables	78		INFO	2
BUCH	B315	Buchanan	Fixed Tables	78		INFO	2
BIOL	2200	Biological Sciences	Fixed Tables	76		INFO	2
LSK	460	Leonard S. Klinck	Moveable Tables	75		INFO	2
GEOG	212	Geography	Fixed Tables	72		INFO	2
MCML	160	MacMillan	Fixed Tables	72		INFO	2
ORCH	1001	Orchard Commons	Mixed	72		INFO	2
ORCH	3074	Orchard Commons	Fixed Tables	72		INFO	2
ORCH	4074	Orchard Commons	Fixed Tables	72		INFO	2
PHRM	3208	Pharmaceutical Sciences Building	Moveable Tables	72		INFO	2
ANGU	241	Henry Angus	Fixed Tables	70		INFO	2
ANGU	347	Henry Angus	Fixed Tables	70		INFO	2
ANGU	243	Henry Angus	Fixed Tables	68		INFO	2
ANGU	254	Henry Angus	Moveable Tables	68		INFO	2
ANGU	343	Henry Angus	Fixed Tables	68		INFO	2
ANGU	345	Henry Angus	Fixed Tables	68		INFO	2
OSB1	203	Robert F. Osborne Centre	Moveable Tables	68		INFO	1
SOWK	124	Jack Bell Building for the School of Social	Moveable Tablets	68		INFO	2
SPPH	B151	School of Population and Public Health	Fixed Tables	66		INFO	2
BUCH	D217	Buchanan	Fixed Tables	65		INFO	2
BUCH	D218	Buchanan	Fixed Tables	65		INFO	2
BUCH	D219	Buchanan	Fixed Tables	65		INFO	2
BUCH	D222	Buchanan	Fixed Tables	65		INFO	2
FSC	1001	Forest Sciences Centre	Fixed Tables	65		INFO	2
FSC	1003	Forest Sciences Centre	Fixed Tables	65		INFO	2
FSC	1611	Forest Sciences Centre	Moveable Tables	64		INFO	2
LASR	105	Frederic Lasserre	Moveable Tables	64		INFO	2
FORW	303	Frank Forward	Fixed Tables	63		INFO	2
				#REF!			
CEME	1204	Civil and Mechanical Engineering	Fixed Tables	62		INFO	2
ANGU	234	Henry Angus	Fixed Tables	60		INFO	2
ANGU	291	Henry Angus	Fixed Tables	60		INFO	2
ANGU	295	Henry Angus	Fixed Tables	60		INFO	2
ANGU	334	Henry Angus	Fixed Tables	60		INFO	2
CHBE	103	Chemical and Biological Engineering	Moveable Tables	60		INFO	1
GEOG	101	Geography	Moveable Tables	60		INFO	2
GEOG	147	Geography	Moveable Tables	60		INFO	2
HEBB	116	Hebb	Moveable Tables	60		INFO	2
MATH	102	Mathematics	Moveable Tables	60		INFO	2
SCRF	209	Neville Scarfe	Moveable Tables	60		INFO	2
ANGU	350	Henry Angus	Fixed Tables	58		INFO	2
LIFE	2212	UBC Life Building	Moveable Tables	58		INFO	2
LIFE	2214	UBC Life Building	Moveable Tables	58		INFO	2
BUCH	B208	Buchanan	Fixed Tables	56		INFO	1
HEBB	B112	Hebb	Fixed Tables	56		INFO	2
UCEN	103	The Leon and Thea Koerner University	Fixed Tables	55		INFO	2
ANGU	37	Henry Angus	Fixed Tables	54		INFO	2
ANGU	39	Henry Angus	Fixed Tables	54		INFO	2
FNH	40	Food, Nutrition and Health	Moveable Tablets	54		INFO	1
ALRD	121	Allard Hall	Fixed Tables	50		INFO	2

BUCH	D316	Buchanan	Moveable Tables	50		INFO	1
BUCH	D317	Buchanan	Moveable Tables	50		INFO	2
BUCH	D322	Buchanan	Moveable Tables	50		INFO	2
EOS	135	Earth and Ocean Sciences	Moveable Tables	50		INFO	1
FORW	317	Frank Forward	Moveable Tables	50		INFO	1
IBLC	155	Irving K Barber Learning Centre	Fixed Tables	50		INFO	2
IONA	633	Iona Building	Moveable Tables	50		INFO	2
MCML	158	MacMillan	Moveable Tables	50		INFO	2
SWNG	207	West Mall Swing Space	Moveable Tables	50		INFO	2
ANGU	435	Henry Angus	Moveable Tables	48		INFO	2
BIOL	1012	Biological Sciences	Moveable Tables	48		INFO	2
BUCH	B210	Buchanan	Moveable Tablets	48		INFO	1
MATH	104	Mathematics	Moveable Tables	48		INFO	2
MATH	203	Mathematics	Moveable Tables	48		INFO	2
ORCH	3018	Orchard Commons	Fixed Tables	48		INFO	2
ORCH	4018	Orchard Commons	Mixed	48		INFO	2
SWNG	305	West Mall Swing Space	Moveable Tables	48		INFO	2
SWNG	307	West Mall Swing Space	Moveable Tables	48		INFO	2
SWNG	309	West Mall Swing Space	Moveable Tables	48		INFO	2
SWNG	405	West Mall Swing Space	Moveable Tables	48		INFO	2
SWNG	407	West Mall Swing Space	Moveable Tables	48		INFO	2
SWNG	409	West Mall Swing Space	Moveable Tables	48		INFO	2
UCEN	107	The Leon and Thea Koerner University	Moveable Tables	48		INFO	2
SWNG	105	West Mall Swing Space	Moveable Tables	47		INFO	2
SWNG	107	West Mall Swing Space	Moveable Tables	47		INFO	2
SWNG	109	West Mall Swing Space	Moveable Tables	47		INFO	2
CEME	1215	Civil and Mechanical Engineering	Fixed Tables	45		INFO	2
ALRD	B101	Allard Hall	Fixed Tables	44		INFO	2
ANGU	335	Henry Angus	Fixed Tables	44		INFO	2
ANGU	354	Henry Angus	Fixed Tables	44		INFO	2
ANGU	434	Henry Angus	Fixed Tables	44		INFO	2
FNH	50	Food, Nutrition and Health	Moveable Tablets	43		INFO	1
BUCH	B141	Buchanan	Moveable Tables	42		INFO	1
GEOG	201	Geography	Moveable Tables	42		INFO	2
GEOG	214	Geography	Moveable Tables	42		INFO	2
LSK	462	Leonard S. Klinck	Moveable Tables	42		INFO	2
ANGU	235	Henry Angus	Fixed Tables	41		INFO	2
ANGU	237	Henry Angus	Fixed Tables	41		INFO	2
BUCH	B209	Buchanan	Moveable Tablets	40		INFO	1
BUCH	B211	Buchanan	Moveable Tablets	40		INFO	1
BUCH	B218	Buchanan	Moveable Tablets	40		INFO	1
BUCH	B303	Buchanan	Moveable Tablets	40		INFO	1
BUCH	B309	Buchanan	Moveable Tablets	40		INFO	1
BUCH	B318	Buchanan	Moveable Tables	40		INFO	1
BUCH	D201	Buchanan	Moveable Tables	40		INFO	1
BUCH	D204	Buchanan	Moveable Tables	40		INFO	1
BUCH	D301	Buchanan	Moveable Tables	40		INFO	1
BUCH	D312	Buchanan	Moveable Tables	40		INFO	1
BUCH	D314	Buchanan	Moveable Tables	40		INFO	1
DMP	101	Hugh Dempster Pavilion	Moveable Tables	40		INFO	2
DMP	201	Hugh Dempster Pavilion	Moveable Tables	40		INFO	1
FNH	30	Food, Nutrition and Health	Moveable Tablets	40		INFO	2
IBLC	185	Irving K Barber Learning Centre	Moveable Tables	40		INFO	2
PCN	1001	Ponderosa Commons North: Oak/Cedar	Moveable Tables	40		INFO	2
PCN	1002	Ponderosa Commons North: Oak/Cedar	Moveable Tables	40		INFO	1
PCN	1003	Ponderosa Commons North: Oak/Cedar	Fixed Tables	40		INFO	2
SCRF	1003	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	1004	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	1005	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	1021	Neville Scarfe	Moveable Tables	40		INFO	2

SCRF	1023	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	200	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	201	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	202	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	203	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	204	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	206	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	207	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	208	Neville Scarfe	Moveable Tables	40		INFO	2
SCRF	1328	Neville Scarfe	Moveable Tables	38		INFO	2
ANGU	296	Henry Angus	Moveable Tables	37		INFO	2
ANSO	205	Anthropology and Sociology	Moveable Tables	37		INFO	2
HENN	304	Hennings	Moveable Tables	36		INFO	2
ANGU	292	Henry Angus	Moveable Tables	35		INFO	2
FORW	519	Frank Forward	Moveable Tables	35		INFO	1
CEME	1212	Civil and Mechanical Engineering	Fixed Tables	34		INFO	1
SCRF	205	Neville Scarfe	Moveable Tables	34		INFO	2
ANSO	203	Anthropology and Sociology	Moveable Tables	33		INFO	2
ANGU	293	Henry Angus	Moveable Tables	32		INFO	2
BUCH	B302	Buchanan	Moveable Tablets	32		INFO	1
BUCH	B304	Buchanan	Moveable Tablets	32		INFO	1
BUCH	B306	Buchanan	Moveable Tablets	32		INFO	1
BUCH	B307	Buchanan	Moveable Tablets	32		INFO	1
BUCH	B308	Buchanan	Moveable Tablets	32		INFO	1
BUCH	B310	Buchanan	Moveable Tablets	32		INFO	1
FSC	1002	Forest Sciences Centre	Moveable Tables	32		INFO	1
MCML	256	MacMillan	Moveable Tables	32		INFO	2
MCML	260	MacMillan	Moveable Tables	32		INFO	2
BUCH	D323	Buchanan	Moveable Tables	31		INFO	1
ANGU	437	Henry Angus	Moveable Tables	30		INFO	2
BIOL	1001	Biological Sciences	Moveable Tables	30		INFO	2
BUCH	D205	Buchanan	Moveable Tables	30		INFO	1
BUCH	D207	Buchanan	Moveable Tables	30		INFO	1
BUCH	D213	Buchanan	Moveable Tablets	30		INFO	1
BUCH	D221	Buchanan	Moveable Tables	30		INFO	1
BUCH	D229	Buchanan	Moveable Tables	30		INFO	1
BUCH	D304	Buchanan	Moveable Tablets	30		INFO	1
BUCH	D307	Buchanan	Moveable Tables	30		INFO	1
BUCH	D313	Buchanan	Moveable Tables	30		INFO	1
HENN	301	Hennings	Moveable Tables	30		INFO	2
HENN	302	Hennings	Moveable Tables	30		INFO	2
IRC	B75	P.A. Woodward Instructional Resources	Moveable Tables	30		INFO	2
IRC	G41	P.A. Woodward Instructional Resources	Moveable Tables	30		INFO	2
MATH	105	Mathematics	Moveable Tablets	30		INFO	2
MATH	202	Mathematics	Moveable Tablets	30		INFO	2
MATH	204	Mathematics	Moveable Tablets	30		INFO	2
SPPH	B108	School of Population and Public Health	Fixed Tables	30		INFO	2
SWNG	208	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	210	West Mall Swing Space	Moveable Tables	30		INFO	3
SWNG	306	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	308	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	310	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	406	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	408	West Mall Swing Space	Moveable Tables	30		INFO	2
SWNG	410	West Mall Swing Space	Moveable Tables	30		INFO	2
UCEN	101	The Leon and Thea Koerner University	Moveable Tables	30		INFO	2
UCEN	109	The Leon and Thea Koerner University	Fixed Tables	30		INFO	2
SOWK	222	Jack Bell Building for the School of Social	Moveable Tablets	30		INFO	2
SOWK	223	Jack Bell Building for the School of Social	Moveable Tablets	30		INFO	2
SOWK	224	Jack Bell Building for the School of Social	Moveable Tablets	30		INFO	2

SPPH	143	School of Population and Public Health	Fixed Tables	28		INFO	2
FNH	320	Food, Nutrition and Health	Moveable Tablets	27		INFO	1
SWNG	106	West Mall Swing Space	Moveable Tables	27		INFO	2
SWNG	108	West Mall Swing Space	Moveable Tables	27		INFO	2
SWNG	110	West Mall Swing Space	Moveable Tables	27		INFO	2
ANSO	202	Anthropology and Sociology	Moveable Tables	26		INFO	1
CEME	1206	Civil and Mechanical Engineering	Moveable Tables	26		INFO	1
PONE	127	Ponderosa Annex E	Moveable Tables	26		INFO	1
IBLC	461	Irving K Barber Learning Centre	Moveable Tablets	25		INFO	2
MATH	225	Mathematics	Moveable Tablets	25		INFO	2
ORCH	3002	Orchard Commons	Moveable Tables	25		INFO	2
ORCH	3004	Orchard Commons	Mixed	25		INFO	2
ORCH	3016	Orchard Commons	Fixed Tables	25		INFO	2
ORCH	3052	Orchard Commons	Mixed	25		INFO	2
ORCH	3058	Orchard Commons	Moveable Tables	25		INFO	2
ORCH	4002	Orchard Commons	Fixed Tables	25		INFO	2
ORCH	4004	Orchard Commons	Fixed Tables	25		INFO	2
ORCH	4016	Orchard Commons	Fixed Tables	25		INFO	2
ORCH	4052	Orchard Commons	Mixed	25		INFO	2
ORCH	4058	Orchard Commons	Moveable Tables	25		INFO	2
BUCH	B219	Buchanan	Moveable Tables	24		INFO	1
BUCH	B319	Buchanan	Moveable Tables	24		INFO	1
BUCH	D216	Buchanan	Moveable Tables	24		INFO	1
BUCH	D228	Buchanan	Moveable Tables	24		INFO	1
IBLC	156	Irving K Barber Learning Centre	Moveable Tables	24		INFO	1
IBLC	157	Irving K Barber Learning Centre	Moveable Tables	24		INFO	1
IBLC	158	Irving K Barber Learning Centre	Moveable Tables	24		INFO	1
IBLC	191	Irving K Barber Learning Centre	Moveable Tables	24		INFO	1
MCML	358	MacMillan	Moveable Tables	24		INFO	1
PCN	1008	Ponderosa Commons North: Oak/Cedar	Moveable Tablets	24		INFO	1
PCN	1009	Ponderosa Commons North: Oak/Cedar	Moveable Tables	24		INFO	2
PCN	1011	Ponderosa Commons North: Oak/Cedar	Moveable Tables	24		INFO	1
PCN	1215	Ponderosa Commons North: Oak/Cedar	Moveable Tables	24		INFO	1
PCN	1302	Ponderosa Commons North: Oak/Cedar	Moveable Tables	24		INFO	1
SCRF	1020	Neville Scarfe	Moveable Tables	24		INFO	2
SCRF	204A	Neville Scarfe	Moveable Tables	24		INFO	1
SCRF	210	Neville Scarfe	Moveable Tables	24		INFO	2
BUCH	B216	Buchanan	Moveable Tables	22		INFO	1
BUCH	B316	Buchanan	Moveable Tables	22		INFO	1
BUCH	D209	Buchanan	Moveable Tables	22		INFO	1
BUCH	D214	Buchanan	Moveable Tables	22		INFO	1
BUCH	D306	Buchanan	Moveable Tables	22		INFO	1
BUCH	D315	Buchanan	Moveable Tables	22		INFO	1
BUCH	D319	Buchanan	Moveable Tables	22		INFO	1
BUCH	D325	Buchanan	Moveable Tables	22		INFO	1
CEME	1210	Civil and Mechanical Engineering	Moveable Tables	22		INFO	1
AUDX	157	Auditorium Annex	Moveable Tables	21		INFO	1
IRC	B79	P.A. Woodward Instructional Resources	Moveable Tablets	21		INFO	2
ALRD	112	Allard Hall	Moveable Tables	20		INFO	1
ALRD	113	Allard Hall	Moveable Tables	20		INFO	1
ANGU	339	Henry Angus	Moveable Tables	20		INFO	2
AUDX	142	Auditorium Annex	Moveable Tables	20		INFO	1
FSC	1615	Forest Sciences Centre	Moveable Tables	20		INFO	2
FSC	1617	Forest Sciences Centre	Moveable Tables	20		INFO	1
GEOG	242	Geography	Moveable Tables	20		INFO	1
LASR	211	Frederic Lasserre	Moveable Tables	20		INFO	2
LASR	5C	Frederic Lasserre	Moveable Tables	20		INFO	1
ORCH	4072	Orchard Commons	Mixed	20		INFO	1
BUCH	B312	Buchanan	Moveable Tables	18		INFO	1
FSC	1402	Forest Sciences Centre	Moveable Tables	18		INFO	1

ANGU	232	Henry Angus	Moveable Tables	16		INFO	1
ANGU	332	Henry Angus	Moveable Tables	16		INFO	1
ANGU	432	Henry Angus	Moveable Tables	16		INFO	1
IBLC	460	Irving K Barber Learning Centre	Moveable Tables	16		INFO	1
IRC	G66	P.A. Woodward Instructional Resources	Moveable Tables	16		INFO	1
ORCH	3062	Orchard Commons	Moveable Tablets	16		INFO	2
ORCH	3068	Orchard Commons	Moveable Tablets	16		INFO	2
ORCH	3072	Orchard Commons	Moveable Tablets	16		INFO	2
ORCH	4062	Orchard Commons	Mixed	16		INFO	1
ORCH	4068	Orchard Commons	Moveable Tables	16		INFO	1
SOWK	326	Jack Bell Building for the School of Social	Moveable Tables	16		INFO	2
SPPH	B112	School of Population and Public Health	Moveable Tables	16		INFO	1
SOWK	324	Jack Bell Building for the School of Social	Moveable Tables	16		INFO	1
IRC	G44	P.A. Woodward Instructional Resources	Moveable Tables	14		INFO	1
SPPH	B138	School of Population and Public Health	Moveable Tables	14			2
IBLC	264	Irving K Barber Learning Centre	Moveable Tables	12		INFO	1
IRC	G57	P.A. Woodward Instructional Resources	Moveable Tables	12		INFO	1
IRC	G65	P.A. Woodward Instructional Resources	Moveable Tables	12		INFO	1
SPPH	B136	School of Population and Public Health	Moveable Tables	12		INFO	1
IBLC	265	Irving K Barber Learning Centre	Moveable Tables	10		INFO	1
IRC	G53	P.A. Woodward Instructional Resources	Moveable Tables	10		INFO	1
IRC	G55	P.A. Woodward Instructional Resources	Moveable Tables	10		INFO	1
IRC	G59	P.A. Woodward Instructional Resources	Moveable Tables	10		INFO	1
IBLC	192	Irving K Barber Learning Centre	Moveable Tables	8		INFO	1
IBLC	193	Irving K Barber Learning Centre	Moveable Tables	8		INFO	1
IBLC	194	Irving K Barber Learning Centre	Moveable Tables	8		INFO	1
IBLC	263	Irving K Barber Learning Centre	Moveable Tables	8		INFO	1
IBLC	266	Irving K Barber Learning Centre	Moveable Tables	8		INFO	1
MCML	360C	MacMillan	Moveable Tables	8		INFO	1
MCML	360D	MacMillan	Moveable Tables	8		INFO	1
MCML	360E	MacMillan	Moveable Tables	8		INFO	1
MCML	360F	MacMillan	Moveable Tables	8		INFO	1
MCML	360G	MacMillan	Moveable Tables	8		INFO	1
MCML	360H	MacMillan	Moveable Tables	8		INFO	1
MCML	360J	MacMillan	Moveable Tables	8		INFO	1
MCML	360K	MacMillan	Moveable Tables	8		INFO	1
MCML	360L	MacMillan	Moveable Tables	8		INFO	1
MCML	360M	MacMillan	Moveable Tables	8		INFO	1
MCML	360A	MacMillan	Moveable Tables	6		INFO	1
MCML	360B	MacMillan	Moveable Tables	6		INFO	1