ISYS3401
Information Technology Evaluation

Week 2 Lecture

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Agenda

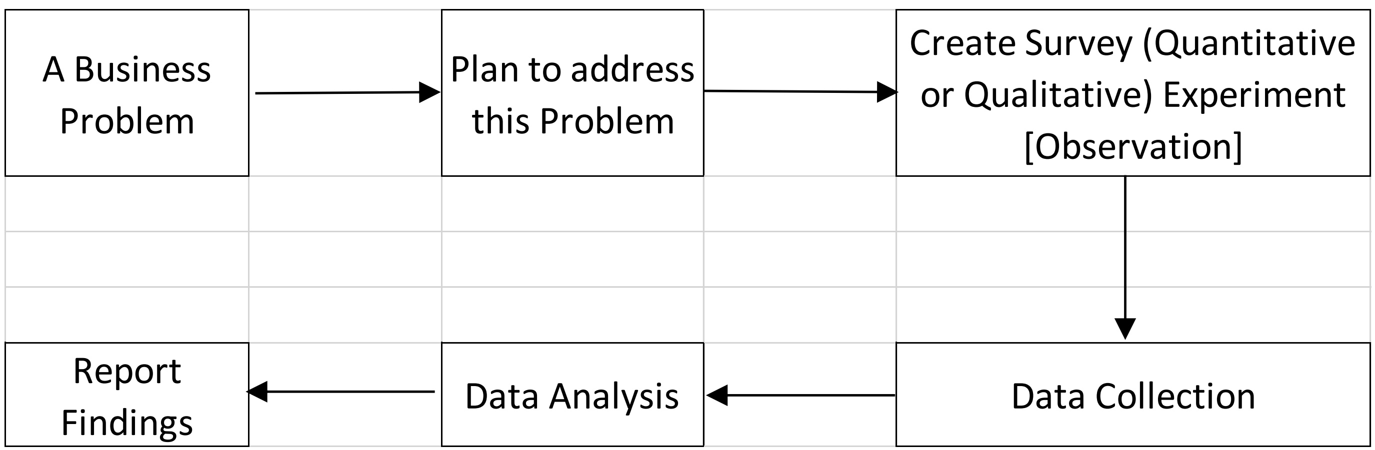
- Basic Types of Variables
- Data Types
- Confidence Intervals
- Different Testing Methods for Different Sample Sizes
- Relationships Between Variables
- Nonparametric Tests
- Graphical Representation
- Class Activities
- Normal Distribution
- Bionomial Distribution

Reference

Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics, by William Albert, Thomas Tullis, ***Chapter 2***

Recap from Last Week Class Activities

Last week, you were asked by Mr Apple to conduct UX Experience (for $10 million).



Remember this?

Basic Types of Variable

Two types of variables :

- **Independent variables** are the things you manipulate or control for, such as the ages of your participants.
- **Dependent variables** are the things you measure, such as success rates, number of errors, and user satisfaction.

Data Types (1)

Four types of data:

- **Nominal (also called categorical) data** are unordered groups or categories, but all you can say they are different, e.g. apples, and oranges.
  - In UX, nominal data can be Windows versus Mac users, or males vs females.
- **Ordinal data** are ordered groups or categories. data are organized in a certain way.
  - In UX, a website might be rated by users as excellent, good, fair, poor, or very poor.
- **Interval data** are continuous data where differences between the values are meaningful, but there is no natural zero point.
  - In UX, System Usability Scale (SUS) has a series of questions on an overall usability of any system with scores range from 0 to 100; or a Likert Scale of 1 to 7.
- **Ratio data** are the same as interval data but with the addition of an absolute zero**.**
  - In UX, examples include age, height, and weight.

Data Types (2)

- Commercial software could define their own standard level of measurement, such as SAS

Name	Measurement Level	Description
ID	Nominal	Control Number
DemGender	Nominal	Gender
DemHomeOwner	Binary	Home Owner
DemAge	Interval	Age
DemMedIncome	Interval	Median Income Region
DemMedHomeValue	Interval	Median Home Value Region

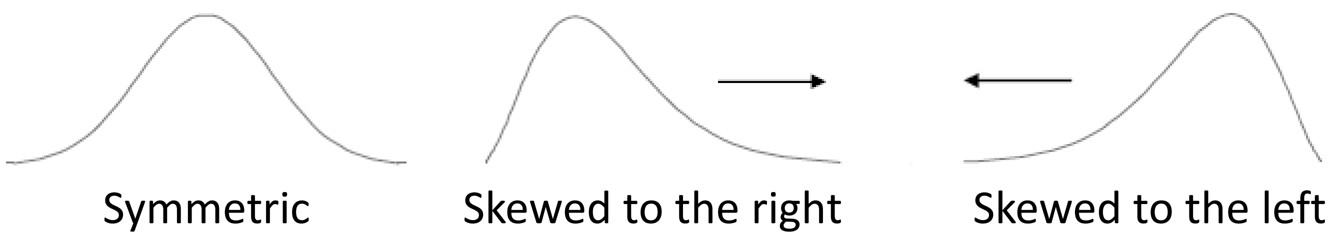
Descriptive Statistics

To measure the data:

- Basic ***descriptive statistics*** such as the mean and median, standard deviation, and the concept of *confidence intervals*.
- Simple ***statistical tests*** for comparing means and analysing relationships between variables.

Measurements

- Which measure of central tendency?
  - Mean or median?
  - Depends on the shape of the distribution



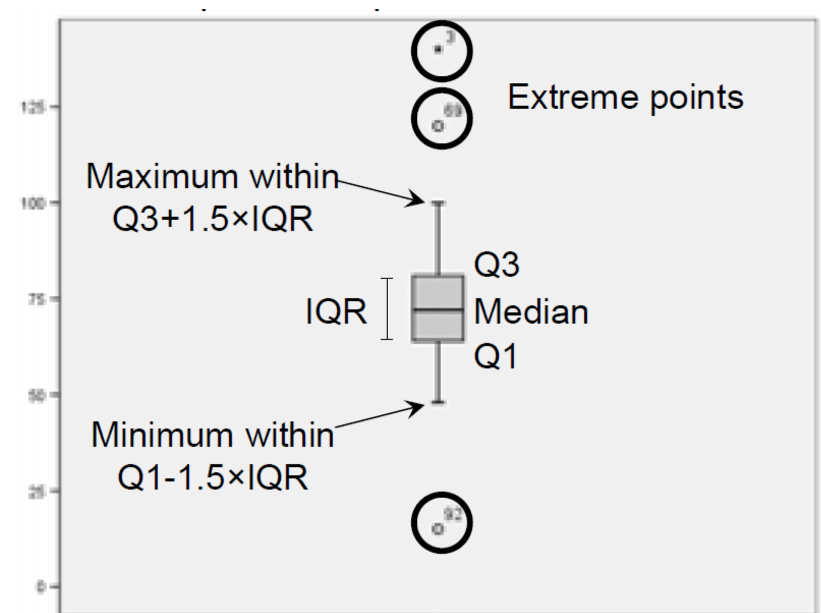
- Variability – spread about the measures of the central location
  - Range = highest – lowest
    - Disadvantages: wastes information
    - Depends on the extreme values
    - Can increase as ***n*** increases
  - Variance & Standard deviation

Measures of Variability

- Sample variance: $$s^2 = \frac{\sum (x - \bar{x})^2}{n - 1}$$
- Coefficient of variation : $$CV = \frac{s}{\bar{x}} \times 100\%$$
- Distribution:

Descriptives

	Statistic
Mean	79.57
Median	79.00
Variance	151.401
Std. Deviation	12.305
Minimum	44
Maximum	121
Range	77
Interquartile Range	14.50



Confidence Intervals

- A **confidence interval** is an estimate of a range of values that includes the true population value for a statistic, such as a mean.
- A confidence interval around that mean to show the range of values that you are reasonably certain will include the true population mean. For example, a confidence level of 95%, means that you want to be 95% certain, or wrong 5% of the time.

Confidence Interval

$\bar{x}$? 95% of sample means will lie in this interval

$\mu - 1.96 \times SE(\bar{x})$ μ $\mu - 1.96 \times SE(\bar{x})$

μ? 95% of such intervals will contain μ

Sample 1: $\bar{x} - 1.96 \times SE(\bar{x})$ $\bar{x}$ $\bar{x} + 1.96 \times SE(\bar{x})$

Sample 2: $\bar{x} - 1.96 \times SE(\bar{x})$ $\bar{x}$ $\bar{x} + 1.96 \times SE(\bar{x})$

Sample 3: $\bar{x} - 1.96 \times SE(\bar{x})$ $\bar{x}$ $\bar{x} + 1.96 \times SE(\bar{x})$

Sample 4: $\bar{x} - 1.96 \times SE(\bar{x})$ $\bar{x}$ $\bar{x} + 1.96 \times SE(\bar{x})$

Sample 5: $\bar{x} - 1.96 \times SE(\bar{x})$ $\bar{x}$ $\bar{x} + 1.96 \times SE(\bar{x})$

$\mu(unknown)$

we construct an interval centred on the sample mean

Comparing Means

- When you want to compare two sets of interval or ratio data (or samples), one of common ways is to compare different means.
- However, the key question remains, are you trying to compare Is the comparison ***within the same set of users*** or ***across different users***?:
  - When comparing data for men vs women, it is highly likely that these are different users, we call this: ***independent samples***.
  - When comparing data for the *same* group of users on different products or designs, like do you like iPhone or Android, we call this: ***paired samples***.

Different Testing Methods for Different Sample Sizes

- If you are only comparing two samples, use a ***t* test**.
- If you are comparing three or more samples, use an analysis of variance (also called **ANOVA**).
- Data are distributed **normally** and the **variances** are approximately equal.

Relationships Between Variables

- You normally have a number of variables in your survey questions, you want to know if some of these are related to one another.
- You might want to see if there are any relationship between two variables, income and education, or we call this: **Correlations**.
- A measure for the strength of the relationship between these variables is $\boldsymbol{R^2}$ **(R Square)**.
- Data are distributed **normally** and the variances are approximately **equal**.

Nonparametric Tests

- Nonparametric tests are used for analysing nominal and ordinal data.
  - For example, you might want to know if a significant difference exists between women and men for success and failure on a particular task.
- The distribution **is not normal** for nominal or ordinal data.
- The **χ2** (pronounced "chi square") **test** is used when you want to compare nominal (or categorical) data.

Graphical Representation [pp.32-40]

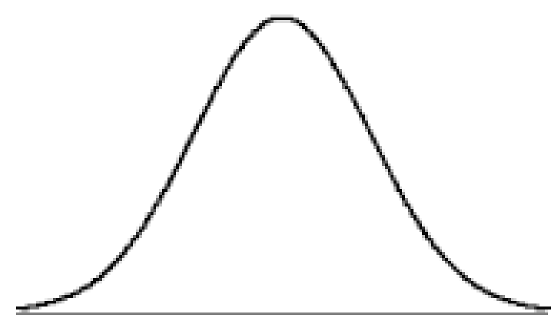
- Column or bar graphs
- Line graphs
- Scatterplots
- Pie or donut charts
- Stacked bar or column graphs

Statistics Recap…

- Normal Distribution
- Binomial Distribution

Normal Distribution (1)

- The ***most*** important continuous distribution is the Gaussian distribution, often known as the Normal distribution. The Normal distribution has two main features:
  - Symmetry about its mean
  - Bell-shape



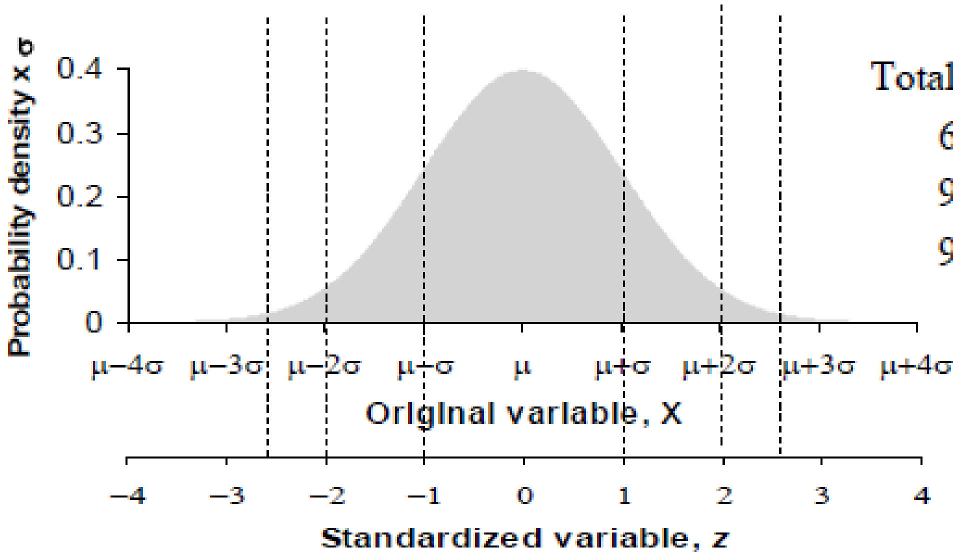
- The Normal distribution is important because many continuous variables have this distribution

Standardised Normal Deviate (2)

- The Normal distribution is summarized by 2 parameters:
  - Mean (μ)
  - Standard deviation (σ)
- We often need to find areas under the Normal distribution curve, particularly in the tails
- Use published tables which are given in most statistical texts (Not needed in this unit)

Standardised Normal Deviate (3)

- Do this by calculating a standardised Normal deviate (SND) given by: $z = \dfrac{x-\mu}{\sigma}$
- z is from a standard Normal distribution with
  - Mean = 0
  - Standard deviation = 1



Total area under the curve = total probability = 1

68% between $\mu-\sigma$ and $\mu+\sigma$

95% between $\mu-1.96\sigma$ and $\mu+1.96\sigma$

99% between $\mu-2.58\sigma$ and $\mu+2.58\sigma$

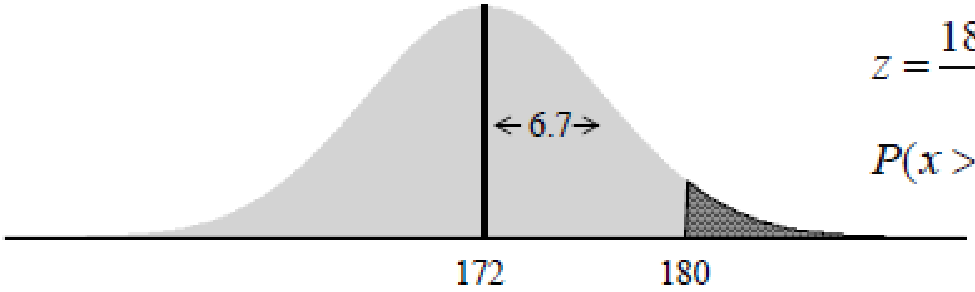
Using Tables (4)
Normal Distribution

- Tables of the Normal distribution use the standardized Normal deviate, *z*

- The quantity tabulated is the ***area*** under the ***upper*** *tail of the probability* density curve, i.e. the probability of obtaining a SND greater than *z*
- **NOTE:** since the curve is symmetrical, the probability in the lower tail (below *–z) is equal to that in the upper tail (above z)*

Example (5)

- The heights of a population of men are approximately normally distributed with mean 172cm and standard deviation 6.7cm. What proportion of men would have heights above 180cm?



$$z = \frac{180-172}{6.7} = 1.19$$

$$P(x > 180) = P(z > 1.19) = 0.1170$$

z	0.00	.....	0.08	0.09
1.0	0.1587	.....	0.1401	0.1379
1.1	0.1357	.....	0.1190	0.1170
1.2	0.1151	.....	0.1003	0.0985

- So, about 12% of men would be expected to be over 180cm in height.

Binomial Distribution (1)

- The **binomial distribution** with parameters *n* and *p* is the discrete probability distribution of the number of successes in a sequence of *n* in a survey say for yes–no question:
  - For example, “do you like my hairstyle?”
  - Others include True/False, Success/Failure.

Binomial Distribution (2)

- The probability of ***r*** A's in n independent trials is composed of two parts:

$$P(r) = \boxed{\frac{n!}{(n-r)!r!}}\boxed{\theta^r (1-\theta)^{n-r}}$$

Binomial Coefficient:
The number of ways we can choose ***r*** A's and ***n-r*** B's
Note: n!=n(n-1)(n-2)….(n-n-1) & 0!=1

The probability of ***r*** A's and ***n-r*** B's occurring in a particular order

Example: #Boy versus #Girl in IS (3)

- If the probability of a male student studying IS is 0.5172, what is the probability of exactly 3 females and 1 male in a IS project group of four students?
- There are 4 possible family types:

	Composition Probability
FFFM	$0.4828 \times 0.4828 \times 0.4828 \times 0.5172 = 0.4828^{3} \times 0.5172^{1}$
FFMF	$0.4828 \times 0.4828 \times 0.5172 \times 0.4828 = 0.4828^{3} \times 0.5172^{1}$
FMFF	$0.4828 \times 0.5172 \times 0.4828 \times 0.4828 = 0.4828^{3} \times 0.5172^{1}$
MFFF	$0.5172 \times 0.4828 \times 0.4828 \times 0.4828 = 0.4828^{3} \times 0.5172^{1}$

- Summing these probabilities gives us a total of **0.2328** which is the probability of exactly 3 females in a group of 4 students. The same result can be obtained using the formula for the Binomial distribution

Example: #Boy versus #Girl in IS (4)

- If the probability of a male student is 0.5172, what is the probability of exactly 1 male student in a project of four students?
  - A total of four students in the project group means that **n = 4**
  - If a male student is the outcome of interest, then **r = 1**
  - The probability of a male student is **θ = 0.5172**
- The binomial coefficient indicates that there are 4 possible group types that comprise 1 male and 3 females:

$$\frac{n!}{(n-r)!r!} = \frac{4\times 3\times 2\times 1}{(3\times 2\times 1)\times 1} = 4$$

- Applying the formula, we have P(1 male student):

$$\frac{n!}{(n-r)!r!}\times\theta^{r}(1-\theta)^{n-r} = 4\times 0.5172^{1}\times 0.4828^{4-1} = 0.2328$$

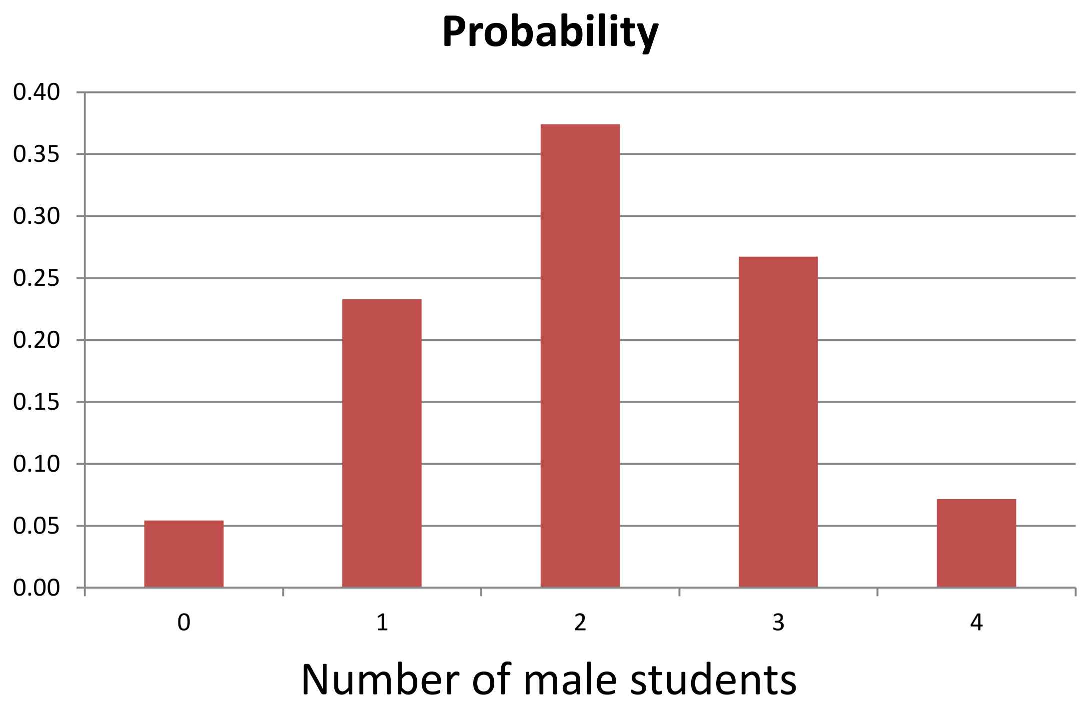
Example: #Boy versus #Girl in IT (5)

- If the probability of a male student is 0.5172, what is the probability distribution for the composition of project groups with 4 students?

Composition		
Male	Female	Probability
0	4	$(0.4828)^4 = 0.0543$
1	3	$4(0.5172)(0.4828)^3 = 0.2328$
2	2	$6(0.5172)^2\ (0.4828)^2 = 0.3741$
3	1	$4(0.5172)^3\ (0.4828) = 0.2672$
4	0	$(0.5172)^4 = 0.0716$
		Total = 1.0000

Example (5)

- The probability distribution can also be displayed graphically:



Expectation (6)

- The mean of a probability distribution is known as the ***expected value*** or ***expectation***. It is the mean of the random variable in the long run, i.e. for a hypothetically infinitely large sample.
- Example binomial $n=4$, $\theta=0.5172$

  $E(r)= \sum[P(r) \times r]$ (number of male students in IS a project group)

  $=(0.0543 \times 0) + (0.2328 \times 1) + (0.3741 \times 2) + (0.2672 \times 3) + (0.0716 \times 4)$

  $= 2.0689$ number of male students
- In general, $E(r) = n\theta$

Variance (7)

- A probability distribution (or more precisely its associated random variable) has a variance, defined as the mean squared difference of the value from the mean
- For binomial $SD(r) = \sqrt{n\theta(1-\theta)}$
- Example: binomial $n=4$, $\theta=0.5172$, mean=2.0689

$SD(r) = \sqrt{4 \times 0.5172 \times (1-0.5172)}$

$= 0.9994$

Binomial Distribution (8)

If you still need further explanation on Binomial Distribution, have a look at this alternative explanation: https://www.youtube.com/watch?v=J8jNoF-K8E8

Next Week

- Planning (for your survey or experiment)
- Hypotheses
- t-test
- McNemar’s Test
- $\chi 2$ test

Testing Methods (σ unknown)

For Evaluation Studies

	One Sample	
	Continuous variable	**Binomial variable**
One sample	Estimate ***s*** from the sample and use the student's ***t***	Normal approximation to Binomial (equivalent to χ^2 test)

	Two Samples (to be compared)	
	Continuous variable	**Binomial variable**
Paired samples	Normally distributed (approximately) Paired ***t*** test	McNemar's test
Independent samples	Normally distributed (approximately) 2-sample ***t*** test	2 samples χ^2 test (2 x 2 table) Comparison of 2 proportions