

Transitioning to University: Teaching Statistics to Economists

INERME Workshop 2024

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Content

- Motivation
- Let's look at some ILDs
- The Student Experience
- Future Developments

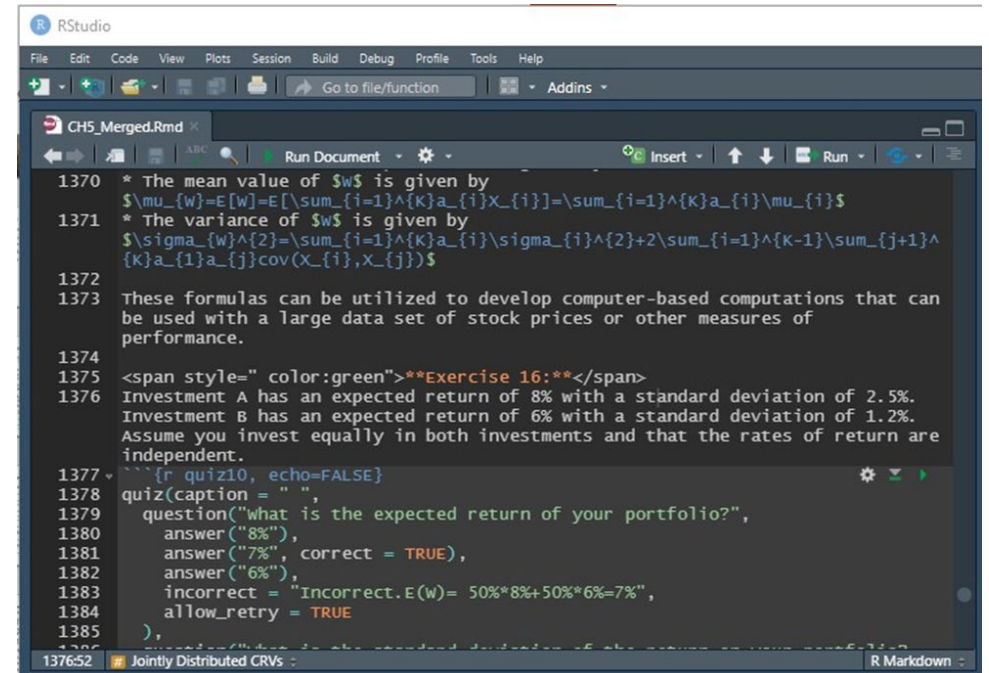


Motivation

- Overall, transitioning to university in the UK can be an exciting but challenging time. Universities typically offer support services such as academic skills workshops, counselling, student finance advice, and social programs to help ease this transition: Mathematics/Statistics Inductions, Mathematics Help-Desk etc..
- **Student Retention:** A smooth transition reduces dropout rates, ensuring students stay enrolled and progress through their studies.
- **Academic Success:** Helping students adapt early improves academic performance, leading to higher grades and overall student satisfaction.
- **Student Well-being:** Supporting the transition helps to reduce stress, anxiety, and homesickness, contributing to better mental health and well-being.
- **Institutional Reputation:** Positive student experiences during the transition reflect well on the university, enhancing its reputation and ability to attract future students.
- **Engagement and Belonging:** A successful transition fosters a sense of belonging, encouraging students to engage with the university community, clubs, societies, and academic networks.
- **Graduate Outcomes:** Early support helps students focus on long-term goals like career planning and employability, improving graduate prospects and employment rates

Motivation

- Transition to Academic rigor (maths/stats)
- 20-30% experience personal difficulties
- Social Science students, lack of motivation and passion for mathematics/statistics
- 75% of students express some degree of mathematics anxiety (30% substantial)
- Original context, Covid-19 Pandemic
- Our Approach: We developed ILDs based on Shiny Apps



```

1370 * The mean value of  $W$  is given by

$$\mu_W = E[W] = E[\sum_{i=1}^K a_i X_i] = \sum_{i=1}^K a_i \mu_i$$

1371 * The variance of  $W$  is given by

$$\sigma_W^2 = \sum_{i=1}^K a_i^2 \sigma_i^2 + 2 \sum_{i=1}^{K-1} \sum_{j=i+1}^K a_i a_j \text{cov}(X_i, X_j)$$

1372
1373 These formulas can be utilized to develop computer-based computations that
can be used with a large data set of stock prices or other measures of
performance.
1374
1375 <span style=" color:green">**Exercise 16:**</span>
1376 Investment A has an expected return of 8% with a standard deviation of 2.5%.
Investment B has an expected return of 6% with a standard deviation of 1.2%.
Assume you invest equally in both investments and that the rates of return are
independent.
1377 ```{r quiz10, echo=FALSE}
1378 quiz(caption = " ",
1379     question("What is the expected return of your portfolio?",
1380             answer("8%"),
1381             answer("7%", correct = TRUE),
1382             answer("6%"),
1383             incorrect = "Incorrect. E(W) = 50%*8%+50%*6%=7%",
1384             allow_retry = TRUE
1385             ),
1386     )
1387 ```
1376:52 # Jointly Distributed CRVs : R Markdown

```

ILDs Apps

- Computer Interface

The screenshot shows a web browser window with the URL `127.0.0.1:4109/CH5_Merged.Rmd#section-introduction`. The page title is "Interactive Learning Activity 5".

Interactive Learning Activity 5

Introduction

In this interactive learning activity we will discuss continuous random variables (CRVs) and probability distributions. After completing this ILA you will be familiar with:

1. Notation and expectations of CRVs
2. The Uniform Distribution
3. The Normal Distribution and Approximations
4. The Exponential Distribution
5. Properties of Jointly Distributed Continuous Random Variables
6. Applications

Navigation Menu:

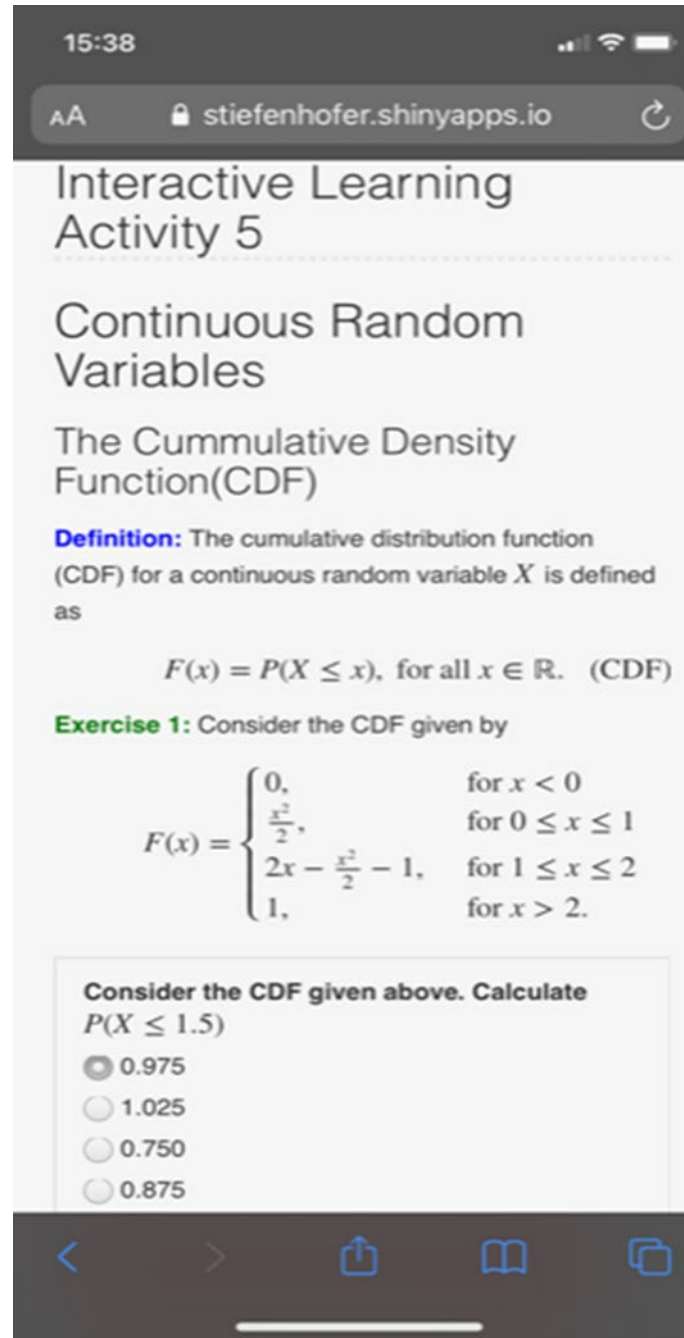
- Introduction (selected)
- Continuous Random Variables
- The Uniform Distribution
- The Normal Distribution
- Approximations
- The Exponential Distribution
- Jointly Distributed CRVs
- Applications

Word Cloud:

The word cloud features the following terms: random, variable, probability, distribution, function, normal, mean, standard, exponential, binomial, size, distributions, exponentially, deviation, cumulative, covariance, bernoulli, form, jointly, density, variance, discrete, proportion, relationship, sample, linear, distributed, continuous, correlation, approximations, normally, uniform, independent.

ILDs Apps

- Mobile Phone Interface



15:38

AA stiefenhofer.shinyapps.io

Interactive Learning Activity 5

Continuous Random Variables

The Cumulative Density Function(CDF)

Definition: The cumulative distribution function (CDF) for a continuous random variable X is defined as

$$F(x) = P(X \leq x), \text{ for all } x \in \mathbb{R}. \quad (\text{CDF})$$

Exercise 1: Consider the CDF given by

$$F(x) = \begin{cases} 0, & \text{for } x < 0 \\ \frac{x^2}{2}, & \text{for } 0 \leq x \leq 1 \\ 2x - \frac{x^2}{2} - 1, & \text{for } 1 \leq x \leq 2 \\ 1, & \text{for } x > 2. \end{cases}$$

Consider the CDF given above. Calculate $P(X \leq 1.5)$

0.975
 1.025
 0.750
 0.875

Properties of ILDs

- Organizing Learning Material
 - Lecture Material**, Definitions, Theorems, Examples
- Engaging with Learning Material through Interactive Learning
 - Dynamic Interactions
 - Quizzes
 - Coding
 - Reproducing own Learning Problems
 - Solved Problems (Video Solutions)
 - Chatbot support (in progress)

Interactive Learning Activity 5

- Introduction
- Continuous Random Variables
- The Uniform Distribution
- The Normal Distribution
- Approximations
- The Exponential Distribution
- Jointly Distributed CRVs
- Applications

Start Over

This ILA is based on the lecture material below. The slides are from "Statistics for Business and Economics", by Newbold P., Carlson W. and Thorne B., ninth Global Edition, Pearson 2020 Chapter 5.

The screenshot displays a presentation interface with four slides:

- Slide 1: Finding Normal Probabilities**
 - Equation: $P(a < X < b) = P\left(\frac{a-\mu}{\sigma} < Z < \frac{b-\mu}{\sigma}\right) = F\left(\frac{b-\mu}{\sigma}\right) - F\left(\frac{a-\mu}{\sigma}\right)$
 - Diagram: A normal distribution curve with a shaded area between a and b on the x-axis. The mean μ is marked at 0.
- Slide 2: Probability as Area Under the Curve**
 - Text: "The total area under the curve is 1.0, and the curve is symmetric, so half is above the mean, half is below"
 - Equation: $P(-\infty < X < \mu) = 0.5$ and $P(\mu < X < \infty) = 0.5$
 - Equation: $P(-\infty < X < \infty) = 1.0$
 - Diagram: A normal distribution curve with the area to the left of the mean μ shaded.
- Slide 3: Appendix Table 1**
 - Text: "The Standard Normal Distribution table in the textbook (Appendix Table 1) shows values of the cumulative normal distribution function"
 - Text: "For a given Z-value a , the table shows $F(a)$ (the area under the curve from negative infinity to a)"
 - Equation: $F(a) = P(Z < a)$
 - Diagram: A normal distribution curve with the area to the left of a shaded.
- Slide 4: The Standard Normal Table**
 - Text: "Appendix Table 1 gives the probability $F(a)$ for any value a "
 - Example: $P(Z < 2.00) = .9772$
 - Diagram: A normal distribution curve with the area to the left of 2.00 shaded, labeled with $.9772$.

Next Topic

Properties of ILDs

- Organizing Learning Material
 - Lecture Material, Definitions, Theorems,
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Interactive Learning Activity 5

- Introduction
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Start Over

Definition: If X is a continuous random variable and the value of its probability density function (PDF) at t is $f(t)$, then the cumulative distribution function (CDF) of X is given by

$$F(x) = P(X \leq x) = \int_{-\infty}^x f(t) dt \text{ for } -\infty < x < \infty. \quad (\text{CDF})$$

Theorem 2: If $f(x)$ and $F(x)$ are the values of the pdf and cdf of X at x , then

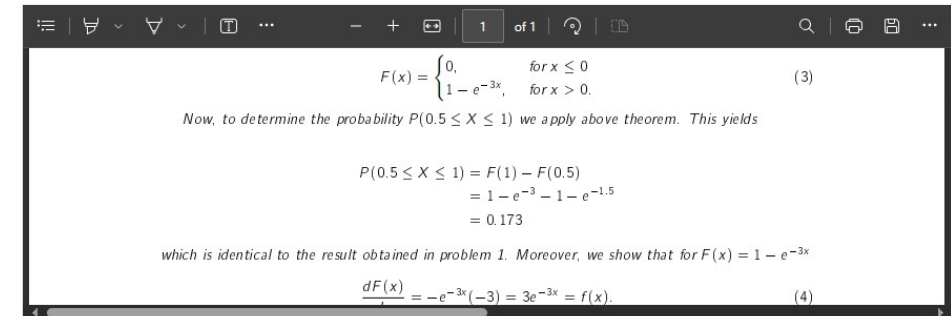
$$P(a \leq X \leq b) = F(b) - F(a)$$

for any real constants a and b with $a \leq b$, and

$$f(x) = \frac{dF(x)}{dx},$$

where the derivatives exists.

Exercise 4: Find the cumulative distribution function of the random variable X , given the probability distribution function in problem 1 and use it to re-calculate $P(0.5 \leq X \leq 1)$.



$$F(x) = \begin{cases} 0, & \text{for } x \leq 0 \\ 1 - e^{-3x}, & \text{for } x > 0. \end{cases} \quad (3)$$

Now, to determine the probability $P(0.5 \leq X \leq 1)$ we apply above theorem. This yields

$$\begin{aligned}
 P(0.5 \leq X \leq 1) &= F(1) - F(0.5) \\
 &= 1 - e^{-3} - 1 - e^{-1.5} \\
 &= 0.173
 \end{aligned}$$

which is identical to the result obtained in problem 1. Moreover, we show that for $F(x) = 1 - e^{-3x}$

$$\frac{dF(x)}{dx} = -e^{-3x}(-3) = 3e^{-3x} = f(x). \quad (4)$$

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Interactive Learning Activity 5

Introduction

Continuous Random Variables

The Uniform Distribution

The Normal Distribution

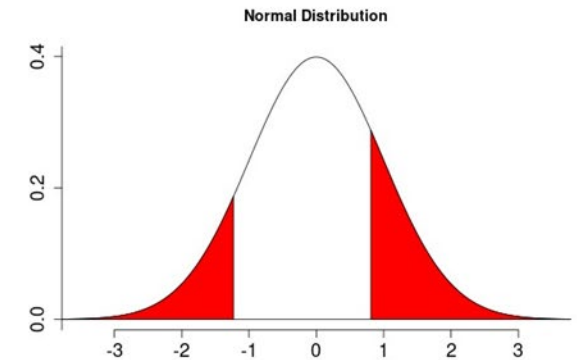
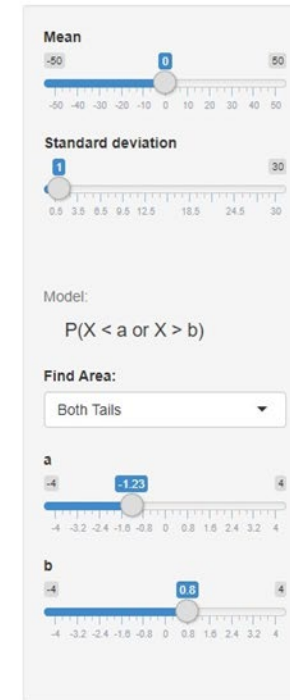
Approximations

The Exponential Distribution

Jointly Distributed CRVs

Applications

Start Over



$$P(X < -1.23 \text{ or } X > 0.8) = 0.321$$

Properties of ILDs

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Interactive Learning Activity 5

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- Start Over

Continuous Random Variables

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Consider the CDF given above. Calculate $P(X \leq 1.5)$

- 0.975
- 0.750
- 0.875

Incorrect. $P(X \leq 1.5) = F(1.5) = 0.875$

Try Again

Calculate $F(2)$

- 1
- 0.5
- no solution

Submit Answer

Properties of ILDs

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- Start Over

Exercise 5: Provide a sketch of the PDF, $f(x)$, and CDF, $F(x)$ given above in exercises 3 and 4. Check your solutions using the R code provided to you in box below.

```
Code  
1 # Scroll down to see the code
2
3
4
5
6
7
8
9
10
11
12
13
14
15
```

```
Code  
1 # Scroll down to see the code
2
3
4
5
6
7
8
9
10
11
12
13
14
15
```

Properties of ILDs

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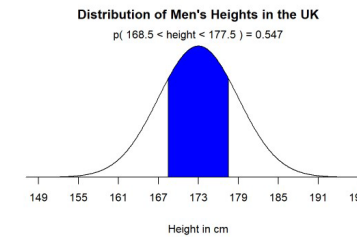
Interactive Learning Activity 5

- Introduction
- Continuous Random Variables
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Start Over

Exercise 9: The height of UK men is normally distributed with mean 173 cm and standard deviation 6cm. Calculate $P(168.5 < \text{height} < 177.5)$ and sketch a graph. Use the provided R code in the box below to check your result.

```
Code Start Over Run Code
1 # Scroll down to see the code
2
3
4
5
6
7
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10
11
12
13
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15
16
```



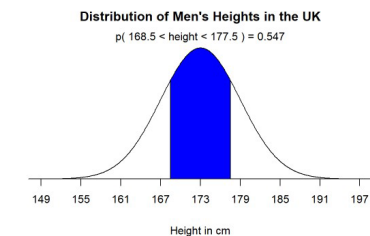
Interactive Learning Activity 5

- Introduction
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Start Over

Exercise 9: The height of UK men is normally distributed with mean 173 cm and standard deviation 6cm. Calculate $P(168.5 < \text{height} < 177.5)$ and sketch a graph. Use the provided R code in the box below to check your result.

```
Code Start Over Run Code
18 # Men's heights are normally distributed with a population mean of 173 cm
19 # and a population standard deviation of 6 cm
20
21 population_mean <- 173
22 population_sd <- 6
23 sd_to_fill <- 0.75
24 lower_bound <- population_mean - population_sd * sd_to_fill
25 upper_bound <- population_mean + population_sd * sd_to_fill
26
27 # Generates equally spaced values within 4 standard deviations of the mean
28 # This is used to connect the points on the curve so the more points the better
29 x <- seq(-4, 4, length = 1000) * population_sd + population_mean
30
31 # Returns the height of the probability distribution at each of those points
32 y <- dnorm(x, population_mean, population_sd)
33
```



Properties of ILDs

- Organizing Learning Material
 - Lecture Material, Definitions, Theorems,
 - Exercises, **Problems, Data Sets**
 - Engaging with Learning Material through Interactive Learning
 - Dynamic Interactions
 - Quizzes
 - Coding
 - Reproducing own Learning Problems
 - Solved Problems (Video Solutions)**
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Interactive Learning Activity 5

Introduction

Continuous Random Variables

The Uniform Distribution

The Normal Distribution

Approximations

The Exponential Distribution

Jointly Distributed CRVs

Applications

Start Over

Problem 3: It is known that amounts of money spent on baby prep and first year of life (FYOL) costs by new parents in the UK in their first year follows a normal distribution with a mean of £5500 and a standard deviation of £2300

- What is the possibility that a randomly chosen parent will spend less than £7000 on baby prep/ FYOL costs?
- What is the probability that a randomly chosen parent will spend more than £6300 on baby prep/ FYOL costs?
- What percentage of parents will spend between £4200 and £6300 on baby prep/ FYOL costs?
- For the yearly spend on baby prep/ FYOL costs by new parents find the cut off point for the top 10% of all yearly spends

The cumulative distribution function, $F(z)$, of the standard normal distribution values needed for these questions are provided in the table below:

Z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549

Chapter 5 Problem 3: function, $F(z)$, of the standard normal distribution table

	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7612	0.7642	0.7672	0.7700	0.7728	0.7754	0.7779	0.7812	0.7823
0.8	0.7858	0.7888	0.7915	0.7941	0.7967	0.7991	0.8013	0.8033	0.8051	0.8078
0.9	0.8106	0.8123	0.8140	0.8156	0.8171	0.8186	0.8199	0.8212	0.8224	0.8236
1.0	0.8247	0.8257	0.8266	0.8274	0.8281	0.8288	0.8294	0.8299	0.8304	0.8308
1.1	0.8311	0.8315	0.8319	0.8322	0.8325	0.8328	0.8331	0.8334	0.8337	0.8339
1.2	0.8341	0.8344	0.8347	0.8349	0.8351	0.8353	0.8355	0.8357	0.8358	0.8359
1.3	0.8361	0.8362	0.8364	0.8365	0.8366	0.8367	0.8368	0.8369	0.8370	0.8371
1.4	0.8372	0.8373	0.8374	0.8375	0.8376	0.8377	0.8378	0.8379	0.8380	0.8381
1.5	0.8381	0.8382	0.8383	0.8384	0.8385	0.8386	0.8387	0.8388	0.8389	0.8390
1.6	0.8391	0.8392	0.8393	0.8394	0.8395	0.8396	0.8397	0.8398	0.8399	0.8400
1.7	0.8401	0.8402	0.8403	0.8404	0.8405	0.8406	0.8407	0.8408	0.8409	0.8410
1.8	0.8411	0.8412	0.8413	0.8414	0.8415	0.8416	0.8417	0.8418	0.8419	0.8420
1.9	0.8421	0.8422	0.8423	0.8424	0.8425	0.8426	0.8427	0.8428	0.8429	0.8430
2.0	0.8431	0.8432	0.8433	0.8434	0.8435	0.8436	0.8437	0.8438	0.8439	0.8440
2.1	0.8441	0.8442	0.8443	0.8444	0.8445	0.8446	0.8447	0.8448	0.8449	0.8450
2.2	0.8451	0.8452	0.8453	0.8454	0.8455	0.8456	0.8457	0.8458	0.8459	0.8460
2.3	0.8461	0.8462	0.8463	0.8464	0.8465	0.8466	0.8467	0.8468	0.8469	0.8470
2.4	0.8471	0.8472	0.8473	0.8474	0.8475	0.8476	0.8477	0.8478	0.8479	0.8480
2.5	0.8481	0.8482	0.8483	0.8484	0.8485	0.8486	0.8487	0.8488	0.8489	0.8490
2.6	0.8491	0.8492	0.8493	0.8494	0.8495	0.8496	0.8497	0.8498	0.8499	0.8500
2.7	0.8501	0.8502	0.8503	0.8504	0.8505	0.8506	0.8507	0.8508	0.8509	0.8510
2.8	0.8511	0.8512	0.8513	0.8514	0.8515	0.8516	0.8517	0.8518	0.8519	0.8520
2.9	0.8521	0.8522	0.8523	0.8524	0.8525	0.8526	0.8527	0.8528	0.8529	0.8530
3.0	0.8531	0.8532	0.8533	0.8534	0.8535	0.8536	0.8537	0.8538	0.8539	0.8540

Solution

The Student Experience

- We conducted a survey with 32 stage 1 students from a cohort of 205
- Introductory Statistics Module ECO1007/2009 delivered at NUBS to economics students
- Students were provided with prototype ILD's designed to support Homework under Remote Emergency Teaching/Learning
- Each ILD is based on a Lecture which was delivered via video
- In addition to video lectures, students attended seminars, and workshops delivered via zoom
- Students report on their "gender", "self-assessed mathematics entry level", and "time spend on learning with the apps". They were asked to assess the ILDs and to compare them to their "usual" homework type

The Student Experience

Q 4: What sentences describe your experience with the Interactive Learning App?

q4: [Its easy to use]

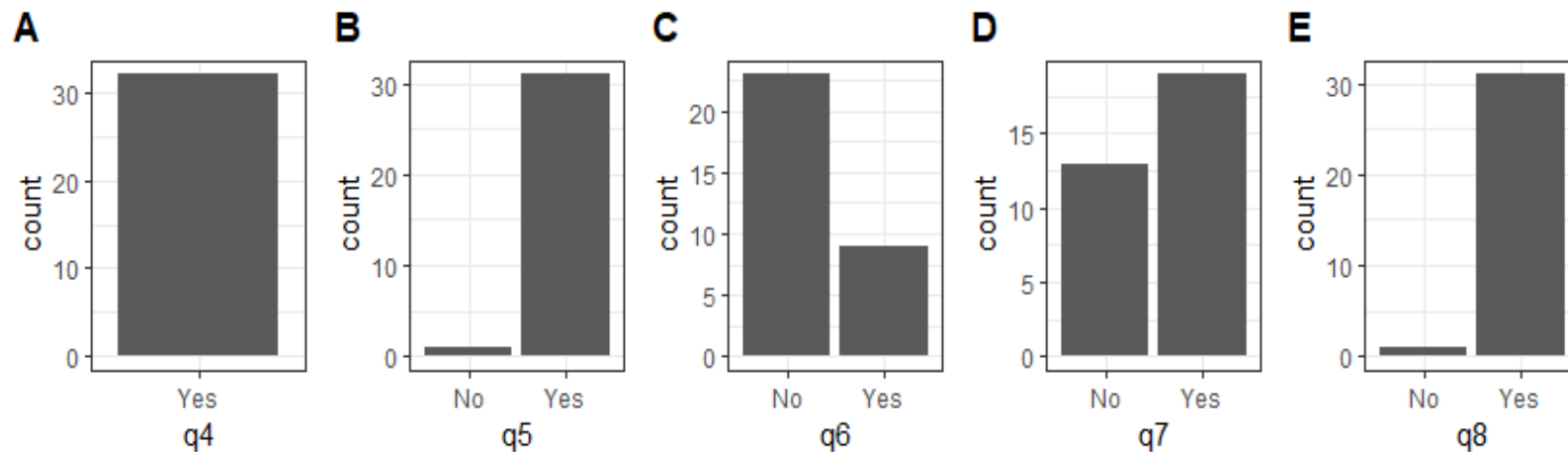
q5: [I feel engaged with my homework]

q6: [It's fun to use]

q7: [It's visually appealing]

q8: [It's easy to navigate]

What sentences describe your experience with the Interactive Learning App?



The Student Experience

Q 5: Comment on the features of the Interactive Learning App (Recall that the App is expected to replace weekly homework activities and not substitute lectures/ tutorials/seminars).

q9: [Recall of definitions and results in compact form]

q10: [Short questions to check understanding of definitions]

q11: [Solutions to multiple choice questions]

q12: [Using pre-written R code to check solutions]

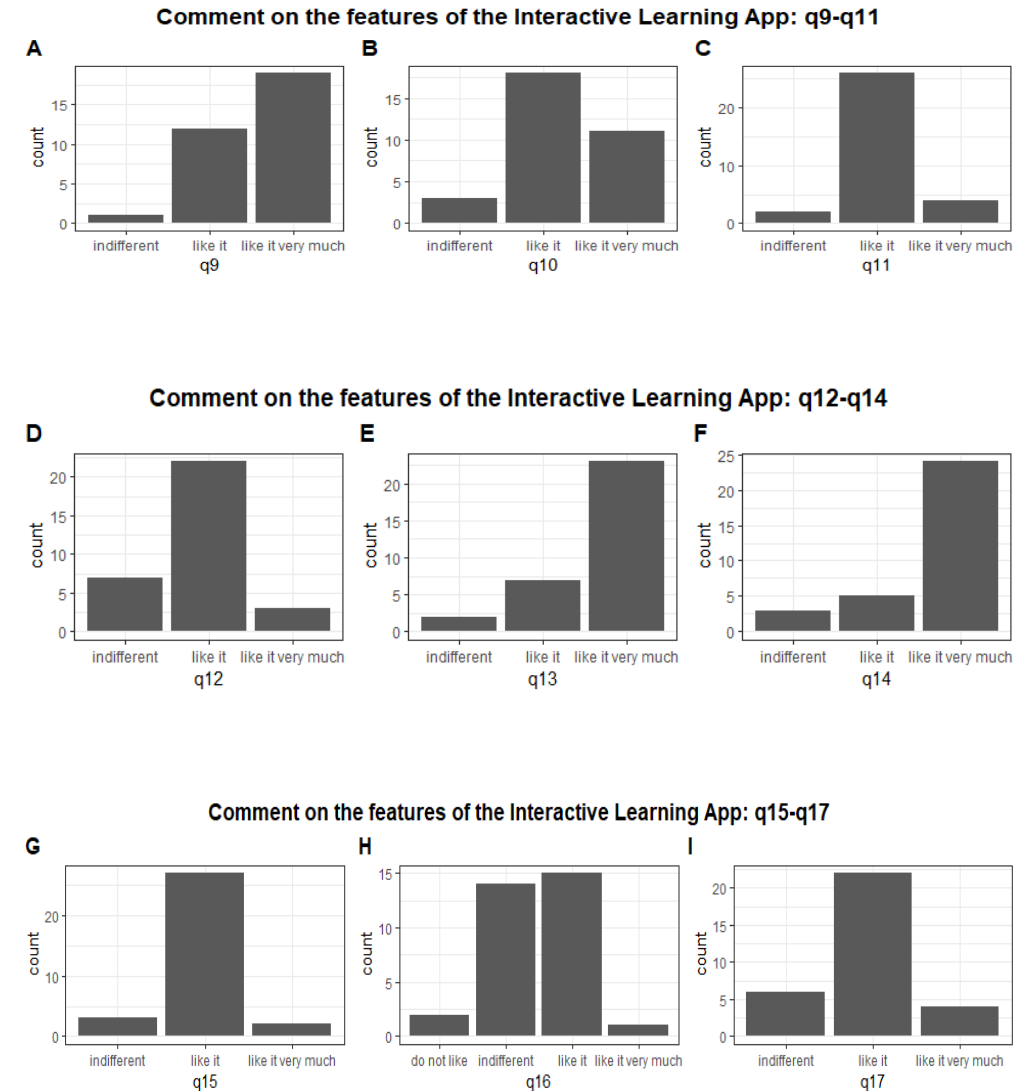
q13: [Embedded pdf files with detailed worked out examples]

q14: [Interactive Dynamic Visualizations where I can choose parameters]

q15: [Applications with video solutions]

q16: [Code boxes (where I can use existing code or write own code)]

q17: [Pre-written code that generates graphs and solutions to problems]



The Student Experience

Q 7: Compared to this year's homework activity what is the expected effect of learning with Interactive Learning Apps on the following: q21-q26

q21: [I will like statistics]

q22: [I will feel insecure when I have to do statistics problems]

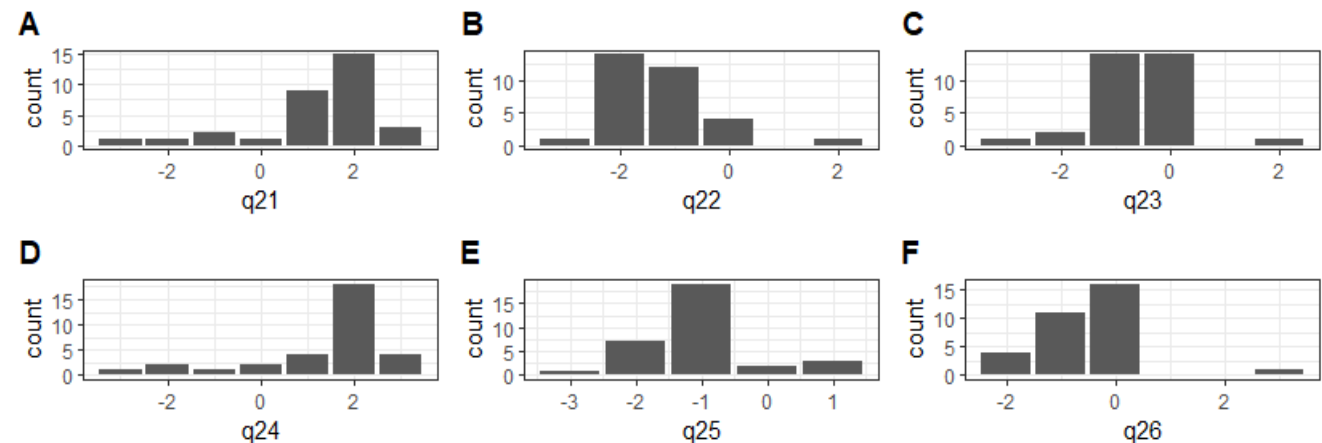
q23: [I will get frustrated going over statistics tests in class]

q24: [I will enjoy taking statistics courses]

q25: [I'm scared by statistics]

q26: [I will be under stress during statistics class]

SATS-36 Survey: Students' feelings concerning statistics



The Student Experience

Q 8: All questions are to be compared to this year's homework activity (quizzes without solutions, group chat room)

q27: [I prefer Interactive Learning Apps (ILDs) to the existing homework type]

q28: [Learning with ILDs improves my confidence]

q29: [ILDs help me better prepare for exams]

q30: [I learn more effectively with ILDs]

q31: [ILDs better help understand difficult statistics concepts]

q32: [ILDs provide more variation in learning]

q33: [ILDs are more effective for exam revision]

q34: [ILDs increase my learning motivation]

	Strongly Agree	Agree	Indifferent	Disagree	Strongly Disagree
q27	14 (44%)	15 (47%)	1 (3%)	2 (6%)	
q28	12 (38%)	16 (50%)	3 (9%)	1 (3%)	
q29	5 (16%)	23 (72%)	4 (13%)		
q30	5 (16%)	16 (50%)	10 (31%)	1 (3%)	
q31	5 (16%)	23 (72%)	4 (13%)		
q32	23 (72%)	8 (25%)	1 (3%)		
q33	14 (44%)	14 (44%)	3 (9%)	1 (3%)	
q34	5 (16%)	19 (59%)	6 (19%)	1 (3%)	1 (3%)

Some Further Analysis

Do ILD's help students reduce statistics anxiety?

Hypothesis: The mean of "Reduction of Statistics Anxiety" is equal to 3

- Cronbach's alpha: 99.17%
- Overall Satisfaction Rate: 76.88%
- Overall mean: 2.02 with variance 0.79
- K-S: D=0.23417, p-value=0.059882
- Data normally distributed
- $t = -11.447$, $df = 31$, p-value = $1.155e-12$
- Reject Null Hypothesis
- CI 95% (1.844, 2.1935)

Table 1: Reduction of statistic anxiety

	1	2	3	4	5	Total	Mean	Variance	Satisfaction rate	Standard error
q21	18	9	1	2	2	32	1.78	1.36	84.38%	0.21
q22	14	12	4	0	2	32	1.88	1.11	81.25%	0.19
q23	3	14	14	0	1	32	2.44	0.62	53.13%	0.14
q24	22	4	2	1	3	32	1.72	1.64	81.25%	0.23
q25	8	19	2	3	0	32	2.00	0.69	84.38%	0.15
q26	4	11	16	0	1	32	2.47	0.69	46.88%	0.15
q28	12	16	3	1	0	32	1.78	0.55	87.50%	0.13
q29	5	23	4	0	0	32	1.97	0.28	87.50%	0.09
q31	5	23	4	0	0	32	1.97	0.28	87.50%	0.09
q34	5	19	6	1	1	32	2.19	0.71	75.00%	0.15
Total	96	150	56	8	10			7.92	76.88%	

Some Further Analysis

Do ILD's help students better manage large and complex quantities of learning material?

Hypothesis: The mean of "OrgInf" is equal to 3

- Cronbach's alpha: 99.19%
- Overall Satisfaction Rate: 87.5%
- Overall mean: 1.8 with variance 0.44
- K-S: D=0.21923, p-value=0.09229
- Data is normally distributed
- $t = -15.864$, $df = 31$, p-value = $2.2e-16$
- Reject Null Hypothesis
- 95% CI (1.6422, 1.9515)

Table 2: Organization of learning context

	1	2	3	4	5	Total	Mean	Variance	Satisfaction rate	Standard error
q9	19	12	1	0	0	32	1.44	0.31	96.88%	0.10
q10	11	18	3	0	0	32	1.75	0.38	90.63%	0.11
q11	4	26	2	0	0	32	1.94	0.18	93.75%	0.08
q27	14	15	1	2	0	32	1.72	0.64	90.63%	0.14
q30	5	16	10	1	0	32	2.22	0.55	65.63%	0.13
q33	14	14	3	1	0	32	1.72	0.58	87.50%	0.13
Total	67	101	20	4	0			2.63	87.50%	

Some Further Analysis

Do ILD's help provide sufficient dynamic interactions for active learning?

Hypothesis: The mean of "DynIntLe" is equal to 3

- Cronbach's alpha: 83.04%
- Overall Satisfaction Rate: 87.5%
- Overall mean: 1.82 with variance 0.32
- K-S: D=0.21011, p-value=0.1185
- Data is normally distributed
- $t = -17.508$, $df = 31$, $p\text{-value} = 2.2e-16$
- Reject Null Hypothesis
- 95% CI (1.6846, 1.9591)

	1	2	3	4	5	Total	Mean	Variance	Satisfaction rate	Standard error
q12	3	22	7	0	0	32	2.13	0.30	78.13%	0.10
q13	23	7	2	0	0	32	1.34	0.35	93.75%	0.10
q14	24	5	3	0	0	32	1.34	0.41	90.63%	0.11
q15	2	27	3	0	0	32	2.03	0.16	90.63%	0.07
q16	1	15	14	2	0	32	2.53	0.44	50.00%	0.12
q17	4	22	6	0	0	32	2.06	0.31	81.25%	0.10
q32	23	8	1	0	0	32	1.31	0.28	96.88%	0.09
Total	80	106	36	2	0			2.24	83.04%	

Future Developments

- Compassionate Language in Chatbots
- Course Support Chatbots

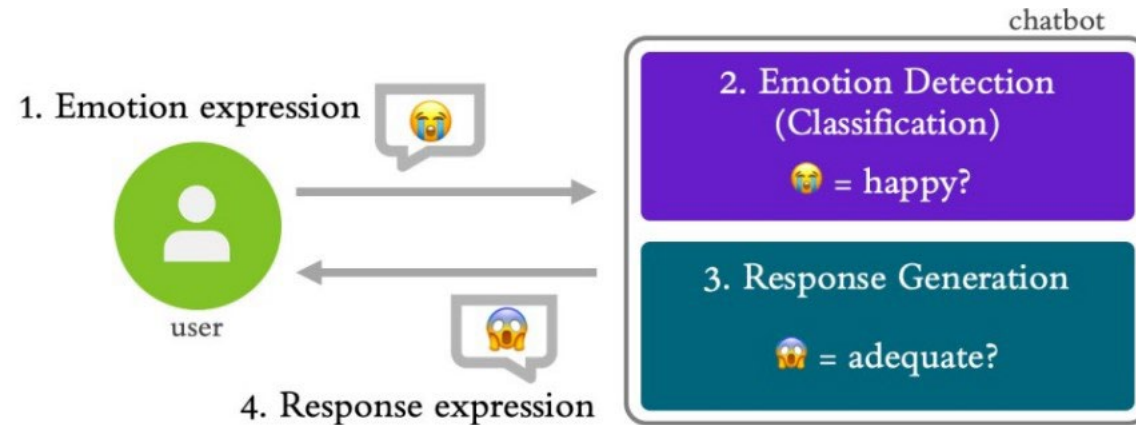


Figure: The 4 Stages of Empathy (Spring et al 2019)

Thank You