

Interactive Learning with R- Markdown and R-Shiny Apps: Statistics for Economics and Business

Developments in Economics Education
Conference 2021

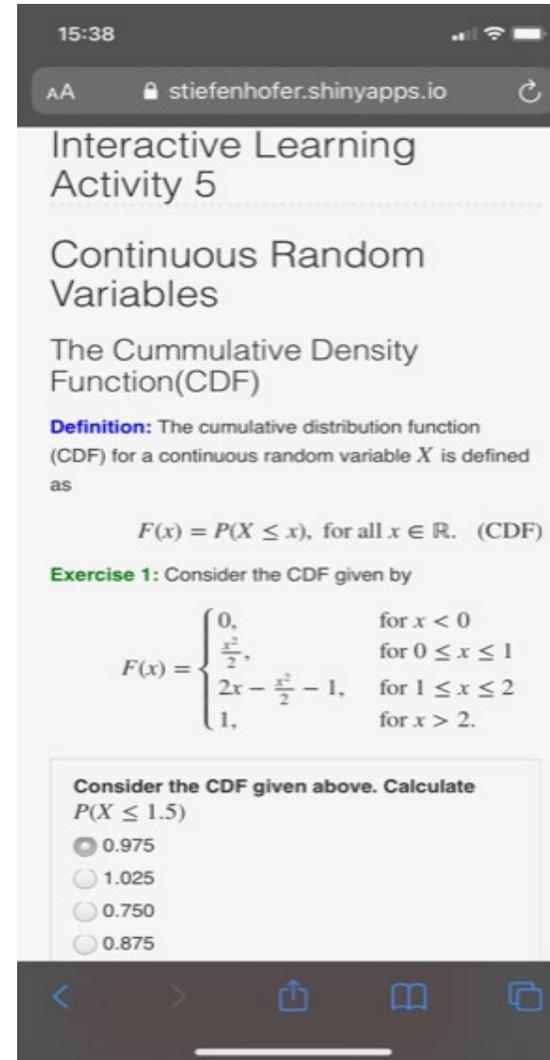
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- Let's look at some ILDs
- Discussion/Questions
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- Discussion/Questions
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Motivation

- The short run context of this research is the rapid shift to full online teaching (Emergency Remote Teaching Policy) due to the Global Covid-19 Pandemic. Support non-smooth functioning Intervention Programs at module level:
 - Opportunity for Active Learning
 - Organize Lecture Material
 - Help reducing Statistics Anxiety (SATS)
- 1) How can we support stage 1 students in their transition to university at module level
- 2) How to utilize more active learning in a human-machine interaction pedagogy in elementary statistics
- The medium term context of this research is to effectively introduce Artificial Intelligence into Learning and Teaching
 - 1) To build “learning algorithms” which support students in a personalized human-machine interaction based learning/teaching
 - 2) To build quality assurance systems for AI based human-machine based pedagogies
- NUBS Digital Innovation Grant

Our Experience in Developing ILDs

- ILDs based R-Studio, R-language, “learnr” package.
 - Narrative, figures, illustrations, and equations
 - Code exercises (R code chunks that users can edit and execute directly)
 - Multiple choice quizzes
 - Videos (supported services include YouTube and Vimeo)
 - Interactive Shiny components
- R-Markdown is easy to learn
 - LaTeX, HTML
- R-Shiny is easy (in principle)
 - shinyApp(ui, server)

Interactive Learning Activity 3

- Introduction
- Basic Definitions
- Probability and its Axioms
- Probability Rules
- Bivariate Probabilities
- Baye's Theorem
- Applications

Definition: Let A and B be two given events. The conditional probability of event A , given that event B has occurred is given by

$$P(A|B) = \frac{P(A \cap B)}{P(B)}, \quad (\text{Conditional probability})$$

where $P(B) > 0$.

Exercise 7:

A fair dice is tossed twice. Find the probability of getting a 4,5, or 6 on the first toss and a 1,2,3, or 4 on the second toss.

- 0.50
- $\frac{1}{3}$
- 0.75

Submit Answer

Statistical independence is a special case for which the conditional probability of A , given B , is the same.

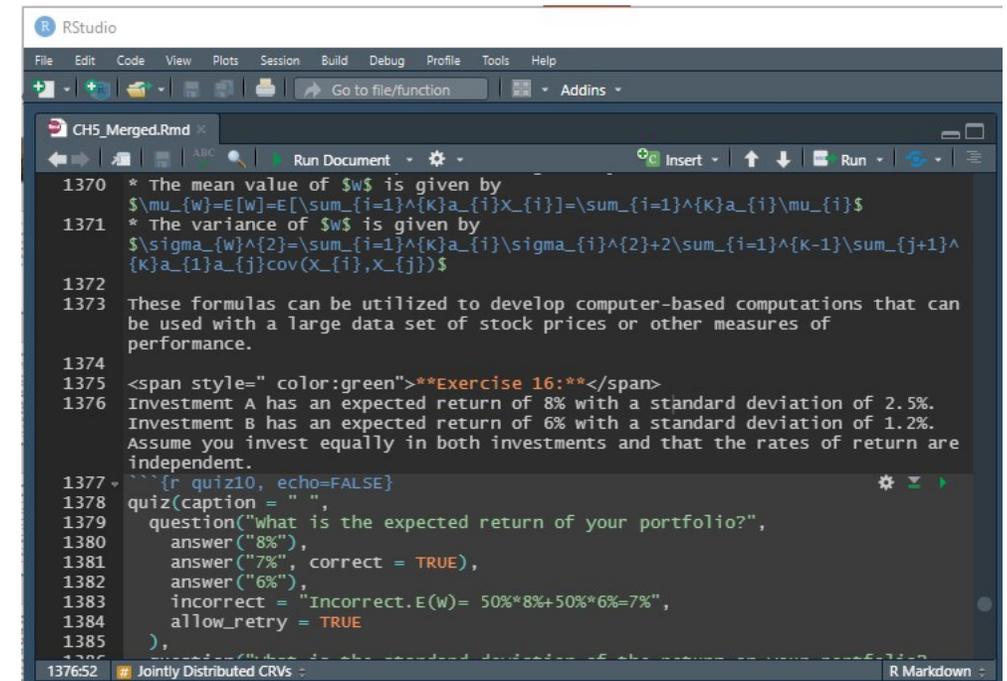
Definition: Let A and B be two events. These events are statistically independent if and only if

$$P(A \cap B) = P(A)P(B).$$

It follows that

$$P(A|B) = P(A)$$

if $P(B) > 0$.

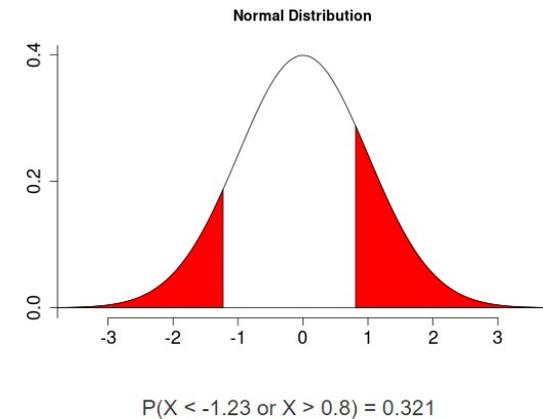
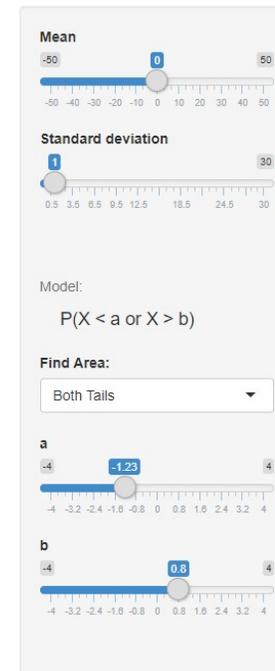


Our Experience in Developing ILDs

- An average ILD consist of
 - Definitions
 - 2-3 R-Shiny “Dynamic Interactions”
 - Examples, Exercises, Applications, PDF documents
- An ILD on average consist of 1'500-1'800 lines of R-Markdown and code
- A Shiny application
 - UI: 150 lines of code
 - Server: 200 lines of code
- On average it took us 40-50 hours per ILD
 - Shiny Applications (developing and debugging)
 - Video Material

Interactive Learning Activity 5

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

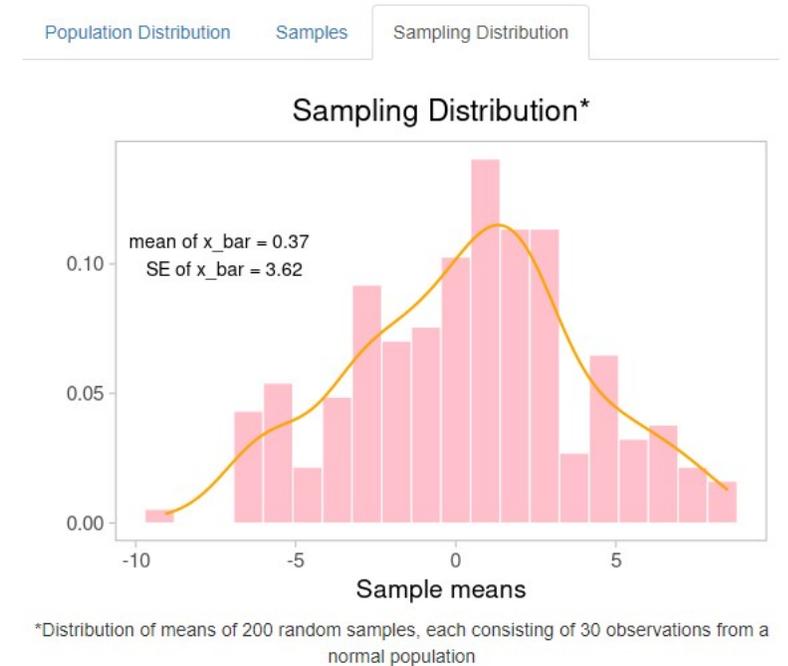
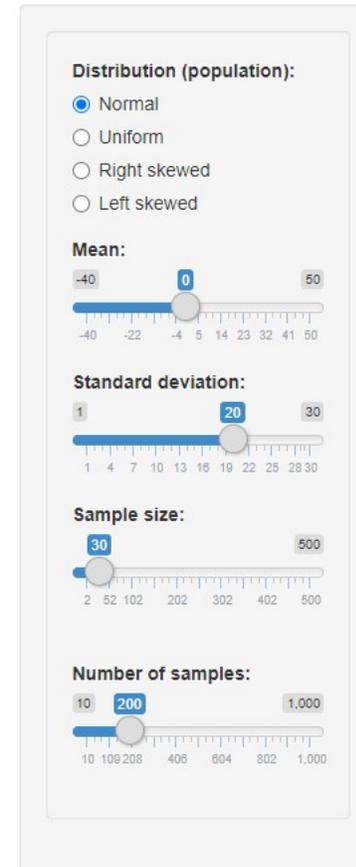


Let's look at some ILDs

- The following ILDs are work in progress:
- Chapter 2
 - Basic Structure, Side Menu, Text, etc.
- Chapter 3
 - “Basic Definitions” Venn Diagram, (under construction), building interactions stepwise
- Chapter 4
 - “Probability Distributions” Table, and Code Boxes
 - “Binomial Distribution” interaction (to build calculations for mean and variance)
- https://stiefenhofer.shinyapps.io/CH5_Merged/
 - “Introduction” pictures, “Continuous Random Variables” Code Boxes to check calculations and check graphs
 - “The Normal Distribution”
- Chapter 6
 - “Sampling Distributions of Sample Means” building interactions stepwise
- Chapter 7
 - “CI for the Mean” building interactions stepwise

Discussion, Share Your Experience

- Developing ILDs takes time
 - Plan ahead
 - May want to develop ILDS iteratively
 - “KAIZEN”, ILDs can always be improved
- Limitations
 - Personalized Learning
 - Cannot automatize equation numbering
 - May need to adjust a few things to work well on mobile phones
 - Not easy to collect data for surveys
- Disadvantages
 - Options to deploy the HTML documents
 - Cannot convert files into other formats easily (print outs, pdf)
 - Cannot run formulas in “embedded” excel files



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]

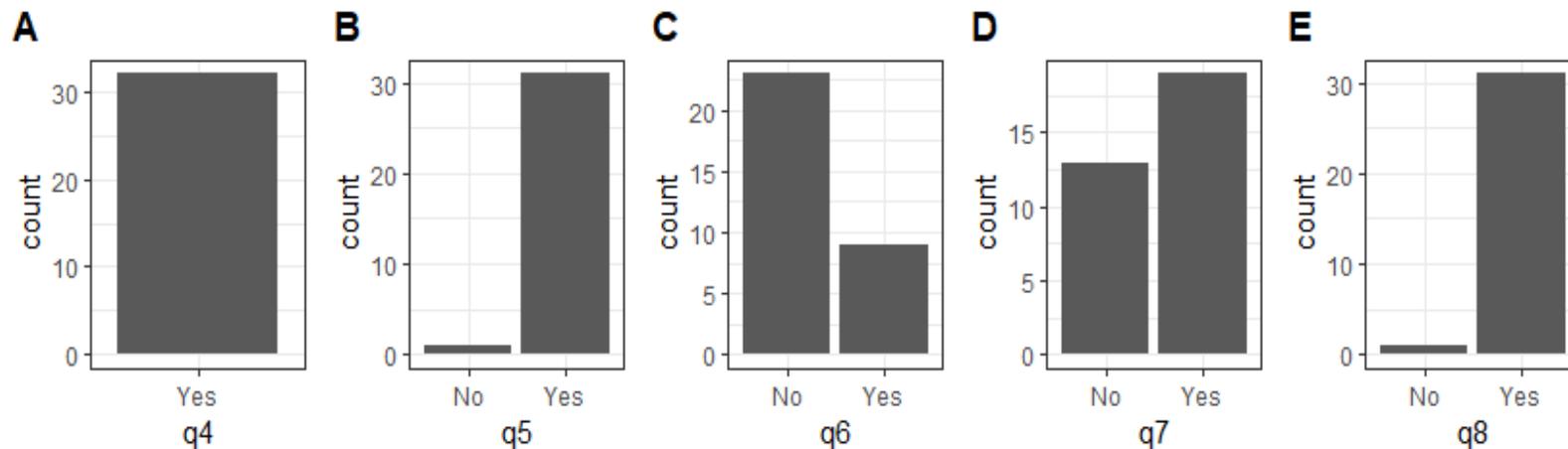
q5: [I feel engaged with my homework]

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]

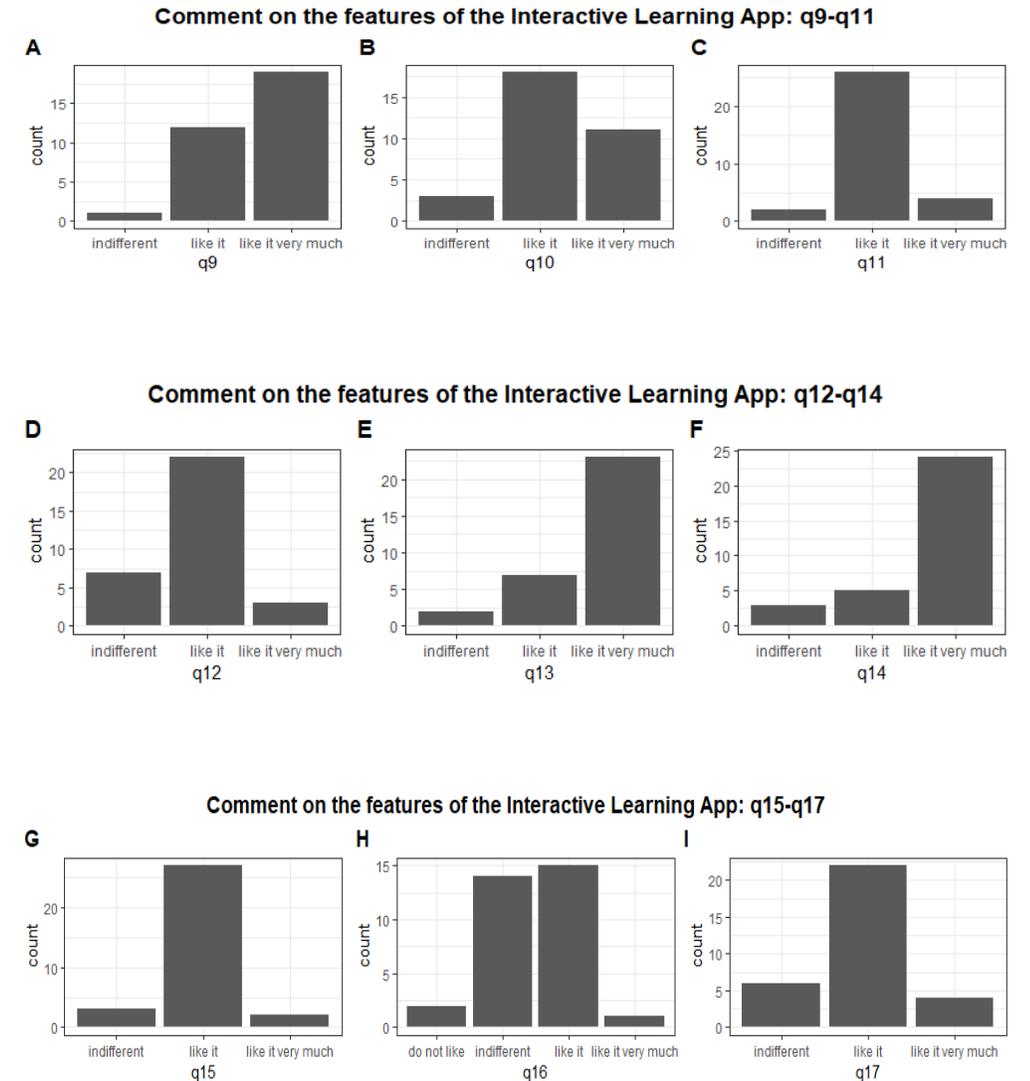
q13: [Embedded pdf files with detailed worked out examples]

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]

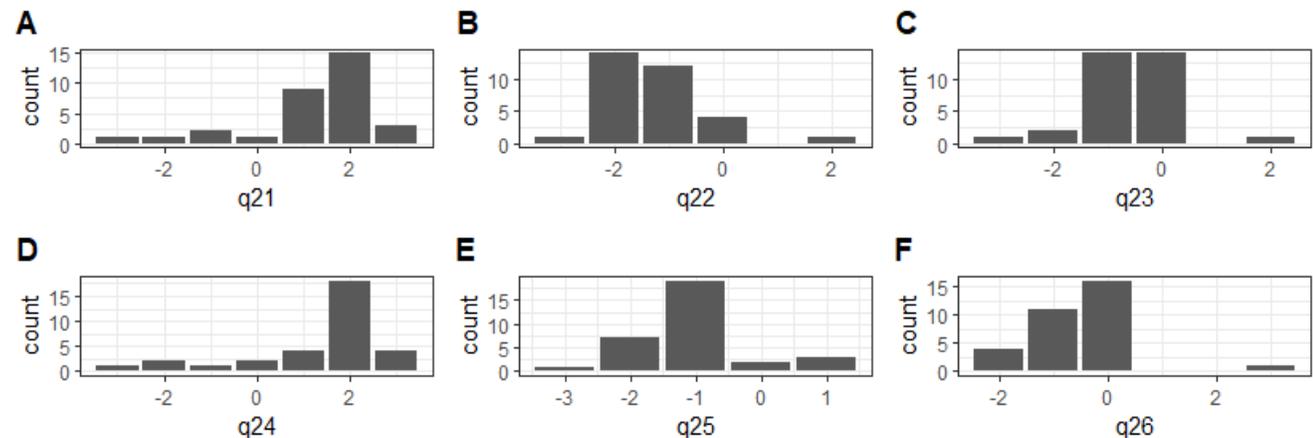
q23: [I will get frustrated going over statistics tests in class]

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-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%	

Discussion, Share Your Experience

- What do your students say about learning with ILD's?

Future Developments

- Link chapters with each other at the click of a button
- Provide links to lecture material (slides)
- Graded Exercises/Applications
- Build Lecture ILDs (Currently Homework/ Remote Learning)
- Provide Open Source Code for Educators
- Optimize Dynamic Interactions (some real world examples)

Thank you for joining this Workshop