

Adaptive learning

- A quantitative assessment of learning impact.

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Overview

- 1 The introstat team
- 2 Learning resources and activities
- 3 Adaptive learning project
- 4 Student use and assessment
- 5 Effect measure

The introstat team

- Formed in 2014
- 4-6 teachers from two sections
- 5 courses/year (2 spring, 2 Autumn, 1 Summer)
- Share teaching and exams
- Maintain learning courses, web-page, book, exercises projects
- 3 different courses (1 Bachelor of engineering, 2 Bachelor of science)
- Total of around 1400 students/year

Learning resources and activities

- The eNote (a traditional style textbook available online)
- Podcasts (video recordings of lectures in Danish and English)
- Weekly/daily lectures
- Quiz's for each Chapter (not available for 02403)
- Weekly agendas with precise reference to sections of the book and solutions to weekly exercises
- Weekly exercises including solutions
- R-code for slides, book examples and solutions
- Access to previous exams, including argued solutions
- 1 or 2 project to be approved to go to the exam

Adaptive learning project


- Start 2018, first student test in 2019.
- 6-7 TA constructing the questions and members of the team following the progress and discussion the results
- Implemented about 800 questions (probes)
- Improve probes by student feedback

Modules

MODULE ↑	OBJECTIVES	PROBES	RESOURCES
Certification - Lasse	12	15	8
Chapter 1: Data visualization	33	45	33
Chapter 2: Functions of random variab...	24	19	0
Chapter 2: Probability and simulation	132	156	123
Chapter 3: Statistics for one and two s...	125	164	119
Chapter 4: Simulation Based Statistics	48	72	48
Chapter 5: Simple Linear regression	73	117	73
Chapter 5: Simple linear regression - ...	4	2	0

Chapter 2: Probability and simulation	Objectives	Resources
Introduction	1	1
Random variable	1	1
Recall what a sample space is	1	1
Identifying the sample space for repeated experiments with dice	1	1
Recall that you do not need to get the same outcome if an experiment is repeated	1	1
Recall that random variables are denoted with capital letters	1	1
Classify variables as random or not	1	1
Define what a random variable is	1	1
Apply a mapping from all outcomes to the value of a random variable	1	1
Recall that an observation is a realization of an experiment	1	1
Classify random variables as discrete or continuous	1	1
Classify sample spaces of random variables as having finite or infinite number of outcomes	1	1
Discrete random variables	1	1
Define the probability density function for a discrete random variable	1	1
Compute the probability density function of a discrete random variable	1	1
Compute the cumulative density function of a discrete random variable	1	1
Compute the probability of a range of outcomes	1	1
Compute the mean value of a discrete random variable	1	1
Define the sample mean	1	1
Compute the variance of a discrete random variable	1	1
Define the sample variance	1	1
Discrete distributions	1	1
Binomial distribution	1	1
Explain parameters in the Binomial distribution	1	1
Recall the formulae for the mean of a binomial distributed random variable	1	1
Compute the mean of a binomial distributed random variable	1	1

Area9: Student perspective


AREA9

RHAPSODE™
CURATOR

100%
PROGRESS: Chapter 2: Pro...
Jan Kloppenborg Møller

JK

←

Coach



Push ▶ for reading content aloud.

What is the correct formula for the mean (μ) of a hypergeometric distribution?

CHOOSE THE CORRECT ANSWER

$\mu = n * a / N$

$\mu = n * p$

$\mu = \sum_{1}^N (x) / N$

$\mu = a / N$

I Know It

Think So

Not Sure

No Idea

Student use

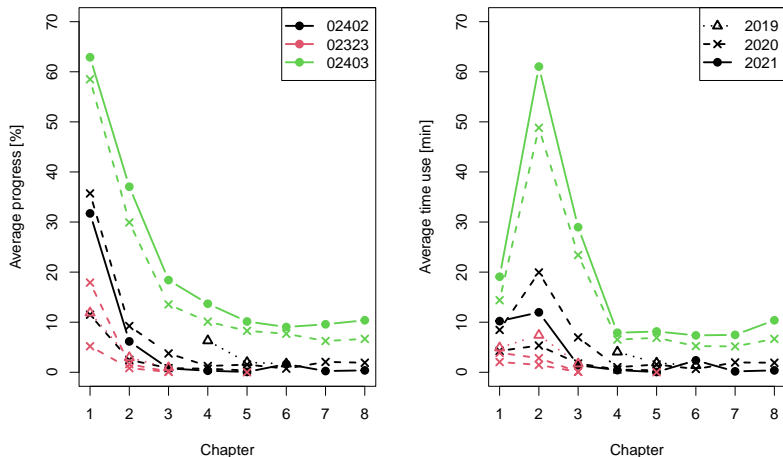


Figure: 02323: Introduction to Statistics (B. Eng.), 02402: Introduction to Statistics (B. Sci.), 02403: Introduction to Mathematical Statistics (B. Sci.)

Student easement

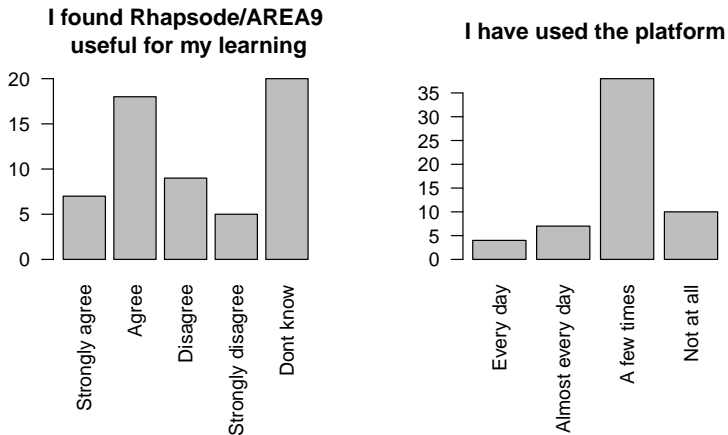


Figure: Evaluation results from 02403, the total number of students were 309.

Table: Main qualitative statements from student evaluation

Positive	Negative
Understanding Helps remember/Repetition Good at adjusting level Result right away Interesting perspective on material Overview and training	Too time-consuming Too long sessions Links to eNote Fields with free text Some errors (spelling and results)

Effects measure

Effects measured by exam performance

- 20 exams
- 693 questions
- 4946 students
- 137,924 answers
- App. 400 students used more 1h on Rhapsode
- Generalized Linear Mixed Effect model controlling for:
 - Study program
 - Chapter
 - Variation between student and questions

Question VII.1 (23)

Which conclusion can be drawn at significance level $\alpha = 5\%$ from this analysis (both conclusion and argument must be correct)?

- There is no significant effect of mix, however there is a significant effect of participant, since the relevant p -values are 0.68 and 0.0083, respectively
- There is neither a significant effect of mix nor participant, since the relevant p -values are 0.093 and 0.17, respectively
- There is both a significant effect of mix and participant as the relevant p -values are 0.0034 and 0.014, respectively
- There is both a significant effect of mix and participant as the relevant p -values are 0.023 and 0.57, respectively
- There is a significant effect of mix, however, there is no significant effect of participant, since the relevant p -values are 0.0045 and 0.85, respectively

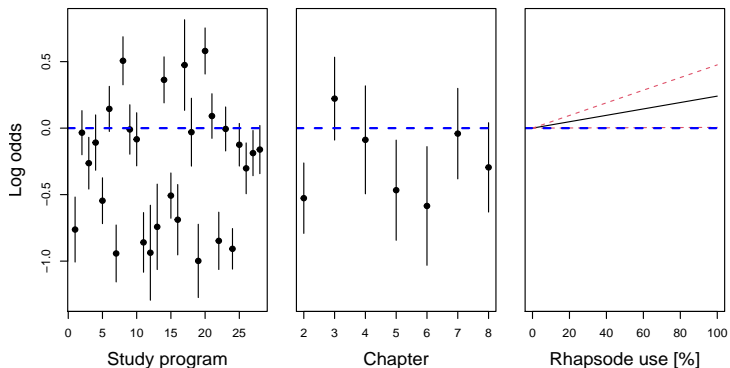
Question VII.2 (24)

How much of the total variation is explained by the model used?

- $\frac{44.7}{20} = 0.393$
- $\frac{7.3 - 3.82 + 77.5 - 11.07}{89.1 - 3.18} = 0.837$
- $\frac{7.3 + 77.5}{89.1} = 0.952$
- $\frac{7.3 + 77.5}{7.3 + 77.5 + 89.1} = 0.488$
- $\frac{1.82 + 11.07 + 3.18}{7.3 + 77.5 + 89.1} = 0.0924$

Effects measure – Results

Log-odds relative to intercept



$$Y_{ij} \sim \text{Binom}(p_{ij}, 1); \quad p_{ij} = \frac{e^{\eta_{ij}}}{1 + e^{\eta_{ij}}}$$

$$\eta_{ij} = \mu + \alpha(i) + \beta(j) + \gamma x_{ij} + a(i) + b(j)$$

$$a(i) \sim N(0, \sigma_a^2) \text{ student effect}$$

$$b(j) \sim N(0, \sigma_b^2) \text{ effect of questions}$$

Discussion and conclusion

- There is borderline significant effect of Area9 use
- Limitations: Limited knowledge about student background, and not randomized
- Feedback from students
 - Positive: testing, repetition, immediate feedback, new perspective
 - Negative: Time consuming, errors, some question types
- Ongoing work: Improve questions based on student feedback, monitor the effect (update effect study)

Thank you!

Questions?

- [1] Jan Kloppenborg Møller, Peder Bacher, Mikkel Lindstrøm Sørensen, and Lasse Engbo Christiansen, (2020), *Adaptive learning in introstat courses at DTU*, Available on request (jkmo@dtu.dk)