Utilizing Open Source Resources to Teach Introductory Data Science

useR! 2022

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About Cornell College

- Small liberal arts college of about 1000 students
- One-Course-at-A-Time block schedule
  - Each class occurs over 3.5 weeks including 18 days of 4 hours of instructional time and three weekends
- New majors in Applied Statistics and Data Science

Course Objectives

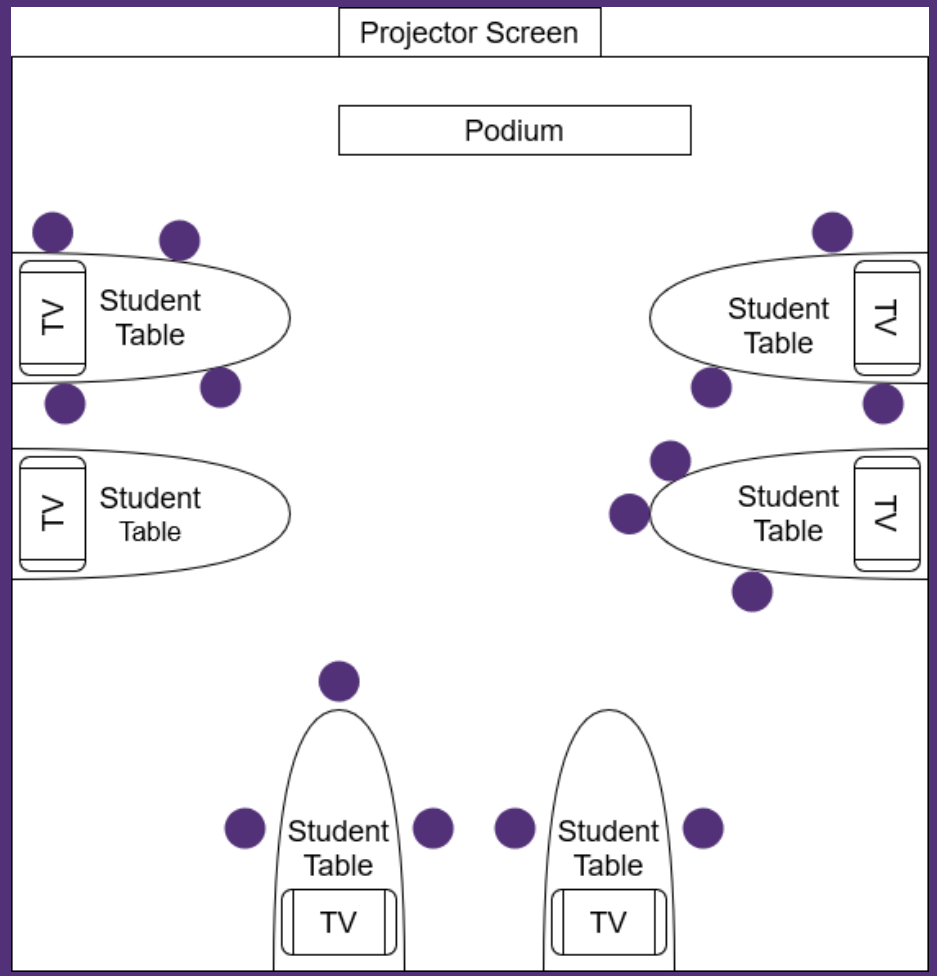
- From the syllabus "respect, explore, understand, and utilize data in a way that is reproducible using version control."
- Data wrangling
- Utilizing version control & good organization to facilitate reproducible work
- Building technical skills in R, and RStudio, namely *tidyverse* functions
- Understanding and learning to consider ethical problems in data science
- Creating understandable and honest data visualizations
- Communicating statistical analysis

Utilized Resources

- Data Science in a Box by Mine Çetinkaya-Rundel (2021)
- Data science ethics assignments from the Quantitative Analysis Institute at Wellesley College (Pattanayak, Gan, Li, Liang, and Wong, 2022)
- Workshops by Julia Silge available at https://juliasilge.github.io/tidytext-tutorial/site/
- Many R packages were use throughout the class but ghclass was particularly useful for teaching/running the course

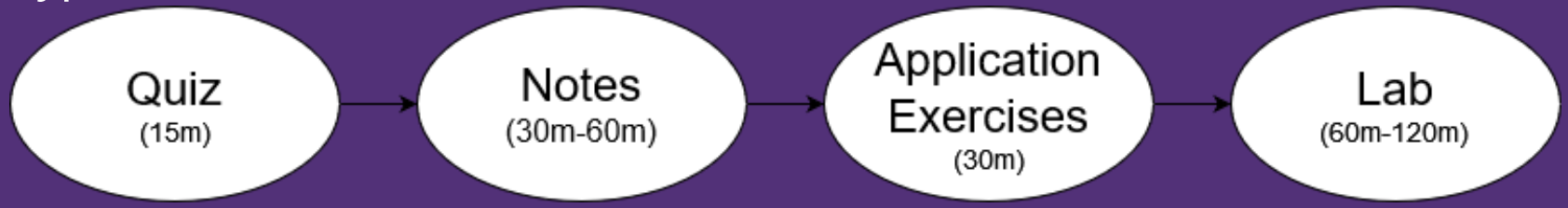
The Class

- This course has a pre-requisite of *either* introductory statistics or introductory computer science (python)
- Total of 15 students



A Day in the Class

- Each day consists of 2, 2 hour sessions.
- Typical class flow:



- After the afternoon class each day students were assigned:
  - One R homework,
  - Read 1-3 chapters of content from sources such as R for Data Science
  - Read ethics related materials

Course Schedule

Day	Topics Covered
Day 1	Meeting R and GitHub (S1-S3,AE1a,L1)
Day 2	Data Visualization (S3-S6,AE2,AE3)
Day 3	Tidy data and Data Wrangling (S7-S11,L2)
Day 4	Data Types and Classes (S12,S13,AE5,L3)
Day 5	Project Meetings
Day 6	Importing and Recording Data (S14,S15,AE6)
Day 7	Effective Visualizations (S16,L4,AE7)
Day 8	Statistical Confounding and Doing Data Science (S17-S19,L5)
Day 9	Web Scraping, Functions, and Iteration (S20-S24,AE8,L8)
Note:	
In reference to Data Science in a Box with S = Slides, AE = Application Exercises, L = Labs	

Course Schedule

Day	Topics Covered
Day 10	Project Meetings and Midterm
Day 11	Data Ethics (S25-S27,Videos,L9)
Day 12	Linear Modeling (S27,S28,L10)
Day 13	Nonlinear Models and Multiple Regression (S29,S30,L11)
Day 14	Prediction, Feature engineering, Cross Validation (S33-S35,L11)
Day 15	Interactive Web Apps (S42-S45, RStudio Shiny Tutorial (RStudio 2021))
Day 16	Text Analysis (Modification of S40,S41 and tidytext workshop (Silge, 2021)
Day 17	Project Presentations
Day 18	Final Exam
Note:	
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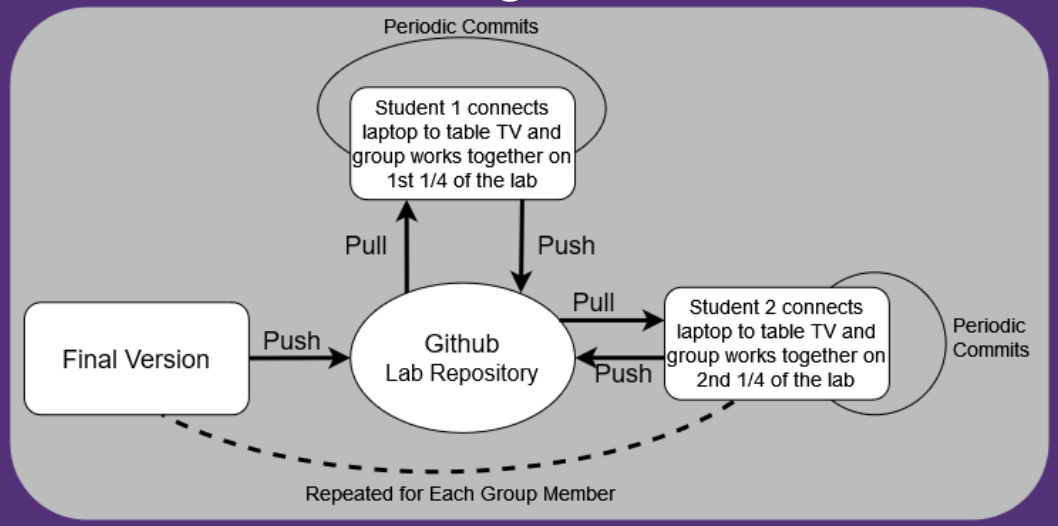
Technologies

- Learning Management System (LMS) - Moodle
- RStudio Server (new implementation for this course, see Çetinkaya-Rundel and Rundel (2018) for a discussion on infrastructure)
  - A combination of RMarkdown and R scripts were used
- Git and Github.
  - Students used Git through the RStudio panel within an R project
  - I also used Github desktop application for some convenience such as pulling one students current work to help them
- R packages - primarily within the *tidyverse*
  - *ghclass* for distributing and collecting repositories (Rundel and Çetinkaya-Rundel, 2022).

Teaching Pedagogies

- Collaborative learning (Roseth, Garfield, and Ben-Zvi, 2008)



Note: This was deviated from for projects and examples to simulate merge conflicts

- Using tidyverse (Çetinkaya-Rundel, Hardin, Baumer, McNamara, Horton, and Rundel, 2021)
- Version control to lead to reproducible work (Beckman, Çetinkaya-Rundel, Horton, Rundel, Sullivan, and Tackett, 2021)

Learning the Bare Necessities

- I was new to Git, Github, RStudio Server (Linux), and a handful of the tidyverse packages and functions
- What did I *need* to learn to teach this class?
  - Git and Github: Basic Git functions such as push,pulling, and handling merge conflicts in RStudio
  - *ghclass* R package made much of the Git/Github learning much smoother. See the R script I created here
  - RStudio server implementation and management required learning some basic Linux commands. See here for the commands I ended up needing
  - Learning the Xaringan R package to modify slides (now I'm using it for this!)
  - I converted the notes to pdf's. See my simple script here. I will host these using Github pages next time.

Student Comments

- "I enjoy working with my group on the project, although it did take countless hours outside of the classroom I enjoyed it a lot and felt accomplished after presenting."
- "Working on labs and application exercises were beneficial for me. After completing those I could refer back to them which helped a lot. When working alone I often would get stuck on a exercise but when working in groups we were able to put our heads together and solve the problems. I really enjoyed that."
- "There were far too many notes in this class."
- "Going over the notes are necessary but I thought the length of the slides were way too long. It was hard to stay engaged the whole time when going over the notes because I was not using the code in r I was just seeing the results on the powerpoint. I think the notes could be trimmed down some to free up more space for application exercises."

Future Updates

- Expanding the ethics discussion in the course
  - I will be working with a Cornell College faculty in Philosophy this summer.
  - Using some modules from (Baumer, Garcia, Kim, Kinnaird, and Ott, 2022)
- Trying out gradetools to make grading quick while giving useful feedback to students (Ricci, Medina, and Dogucu, 2022)
- Less statistical inference and more data wrangling
- Higher project expectations
- Github actions
- Rethinking of exams. The estimated time required was way off.

Acknowledgments

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References

Baumer, B. S., R. L. Garcia, A. Y. Kim, et al. (2022). "Integrating Data Science Ethics Into an Undergraduate Major: A Case Study". In: *Journal of Statistics and Data Science Education* 30.1, pp. 15-28. DOI: 10.1080/26939169.2022.2038041. eprint: https://www.tandfonline.com/doi/pdf/10.1080/26939169.2022.2038041 . URL: https://www.tandfonline.com/doi/abs/10.1080/26939169.2022.2038041 .

Beckman, M. D., M. Çetinkaya-Rundel, N. J. Horton, et al. (2021). "Implementing Version Control with Git and GitHub as a Learning Objective in Statistics and Data Science Courses". In: *Journal of Statistics and Data Science Education* 29.sup1, pp. S132-S144. DOI: 10.1080/10691898.2020.1848485. eprint: https://doi.org/10.1080/10691898.2020.1848485 . URL: https://doi.org/10.1080/10691898.2020.1848485 .

Çetinkaya-Rundel, M. (2021). *Data Science in a Box*. available at https://www.datasciencebox.org.

References

Çetinkaya-Rundel, M., J. Hardin, B. S. Baumer, et al. (2021). *An educator's perspective of the tidyverse*. DOI: 10.48550/ARXIV.2108.03510. URL: https://arxiv.org/abs/2108.03510.

Çetinkaya-Rundel, M. and C. Rundel (2018). "Infrastructure and tools for teaching computing throughout the statistical curriculum". In: *The American Statistician* 72.1, pp. 56-65. DOI: 10.1080/00031305.2017.1397549. eprint: https://www.tandfonline.com/doi/abs/10.1080/00031305.2017.1397549. URL: https://www.tandfonline.com/doi/abs/10.1080/00031305.2017.1397549.

Pattanayak, C., D. Gan, T. Li, et al. (2022). *Quantitative Analysis Institute Online Resources*. Wellesley College. https://sites.google.com/wellesley.edu/qai-online-resources/home?authuser=0.

References

Ricci, F. Z., C. Medina, and M. Dogucu (2022). *gradetools: Tools to Assist with Providing Grades and Personalized Feedback to Students*. https://federicazoe.github.io/gradetools/, https://github.com/federicazoe/gradetools/.

Roseth, C. J., J. B. Garfield, and D. Ben-Zvi (2008). "Collaboration in Learning and Teaching Statistics". In: *Journal of Statistics Education* 16.1, p. null. DOI: 10.1080/10691898.2008.11889557. eprint: https://doi.org/10.1080/10691898.2008.11889557 . URL: https://doi.org/10.1080/10691898.2008.11889557.

RStudio (2020). *Learn Shiny*. https://shiny.rstudio.com/tutorial/.

Rundel, C. and M. Çetinkaya-Rundel (2022). *ghclass: Tools for Managing Classes on GitHub*. R package version 0.2.1, available at https://github.com/rundel/ghclass.

References

Silge, J. (2021). *Text Mining Workshop*. Available at https://juliasilge.github.io/tidytext-tutorial/site/.

Thank You!