Interactive Class Examples with R Shiny to Build Student Intuition

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Background

There are a huge number of great web apps available to aid in teaching students about various statistical concepts. However, many of these may be most useful in a general setting or with specific data / examples. The Shiny package for the R statistical program allows teachers to create their own web apps without having to know any computer languages beyond R. If a teacher is comfortable using R, they can create their own interactive examples for their students. This adds flexibility to how a problem can be presented and allows for an easier process of student discovery than some hands-on activities might.

This poster focuses on two specifics apps I have created with R Shiny to extend in-class activities. The first app is based on "An Exercise in Sampling: Rolling Down the River," an activity created by the 2000 Statistics Institute for the North Carolina School of Science and Mathematics. The second app is based on a version of this activity that was adapted by Dr. Laura Taylor (Elon University) to explore treatment assignment on a smaller 5 x 5 grid.

Both of these activities can be done (and have been) without any sort of app. However, there are two main advantages to creating an app for activities like this:

(i) It saves students time by doing some of the "tedious" calculations for them.

(ii) It enhances exploration by hiding the "true" answers for longer.

With just a little bit of guidance, students can test out several different sampling methods or treatment assignments and compare and contrast their results with classmates. Rather than having to tell the students why we use certain methods, they get to discover it with their classmates.

App 1 – Sampling Methods

Link: https://vank-stats.shinyapps.io/RiverSampling/

Course: STS110 – Intro to Statistical Reasoning

Student Goal: Estimate the overall yield of corn in this field by using different sampling methods to sample 10 of the 100 plots of land.

Purpose: Give students a chance to practice using different sampling methods. Students don't know what the correct answer is, so we can discuss which method is "best"? Students can start to appreciate how random chance means different people get different results even while using the same procedure.

App upon loading | App in use

Result: The same method won't work best for everyone. This allows the class to discuss how we choose between two methods that do equally well "on average." Students can start to guess why stratified sampling worked well when the strata are columns but didn't matter much when the strata were rows. This can be used to create general rules for when stratified sampling is useful.

App 2 – Treatment Assignments

Link: https://vank-stats.shinyapps.io/fertilizer_experiment/

Course: STS325 – Design/Analysis of Experiments

Student Goal: Determine which fertilizer is the best by using different treatment assignment methods.

Purpose: Give students a chance to try different treatment assignment methods. Students often believe completely random assignment is always best. This is their first introduction to the Latin Square design.
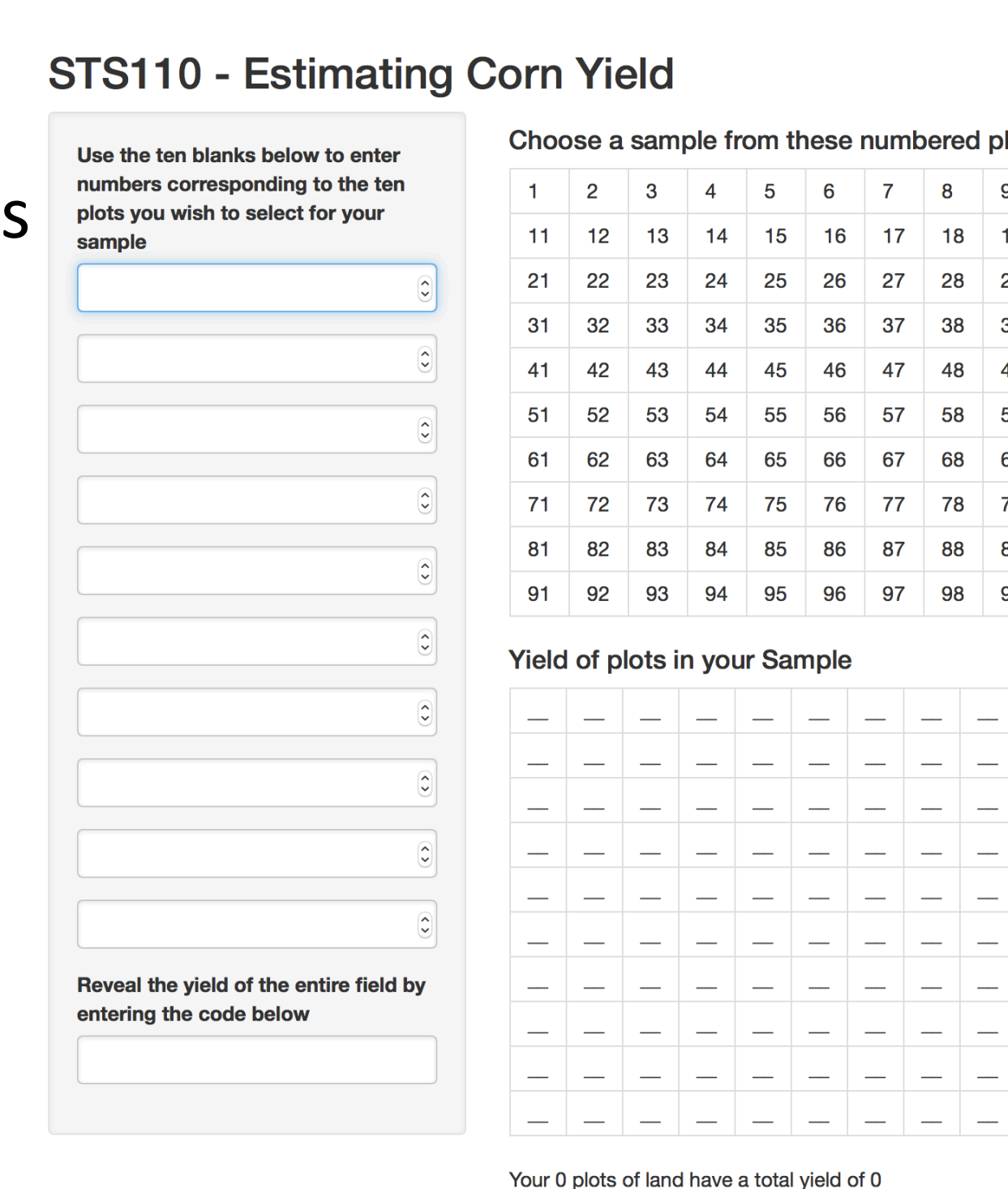

User entered assignment | Random assignment

Result: Just like above, each method won't identify the same best fertilizer for every student. This allows the class to discuss why one method might do better more often while also appreciating random chance and discussing ways of increasing the likelihood we identify the best fertilizer.
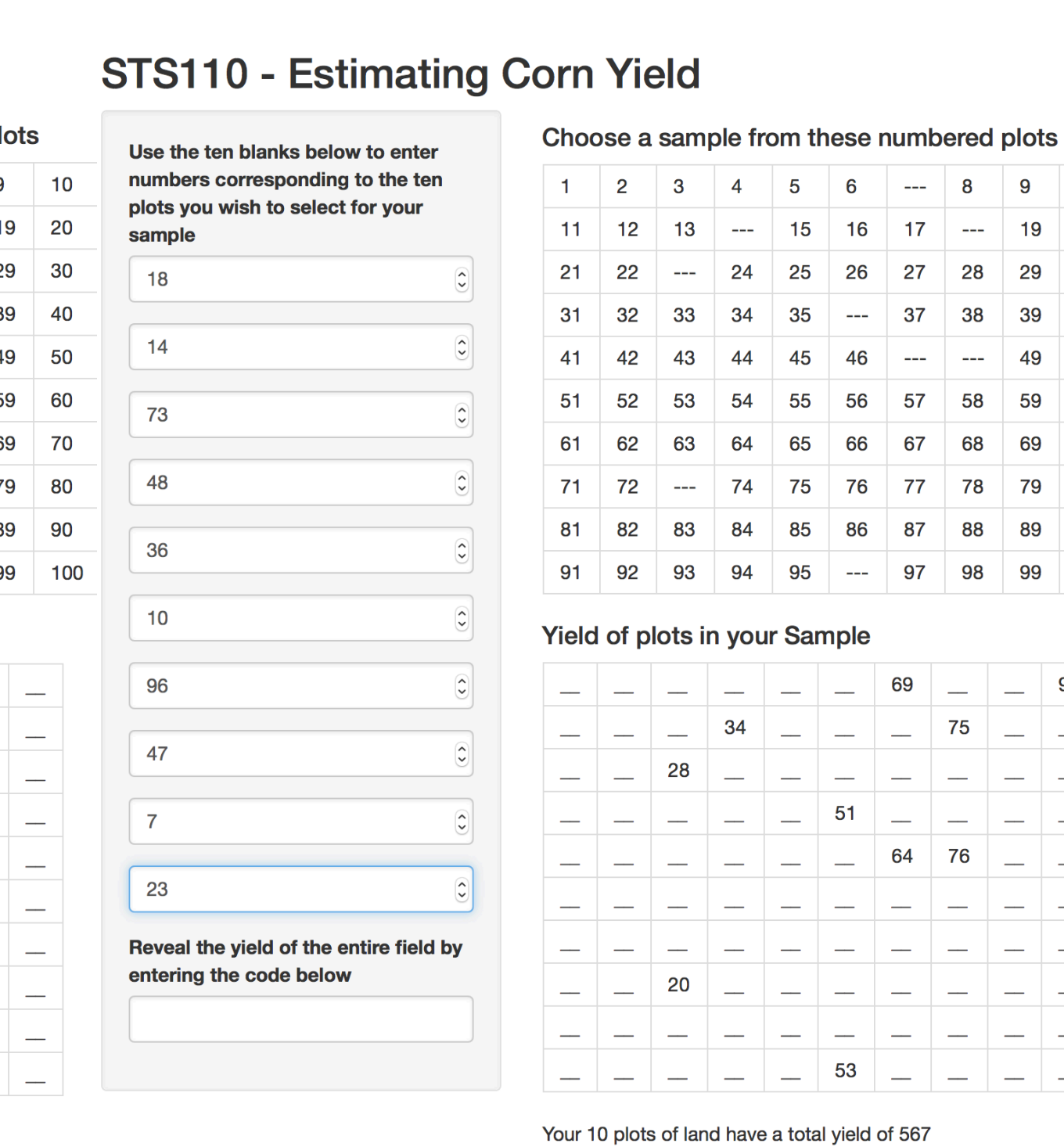
Main Advantage Over a Paper-Based Version

Both apps allow students to *discover* why some methods work better / worse than others in certain situations. I don't need to tell them what the field looks like or how the fertilizers work, the app handles that in the background. They can also develop an appreciation for the role of random chance by trying multiple samples / assignments or by summarizing class results at the end.
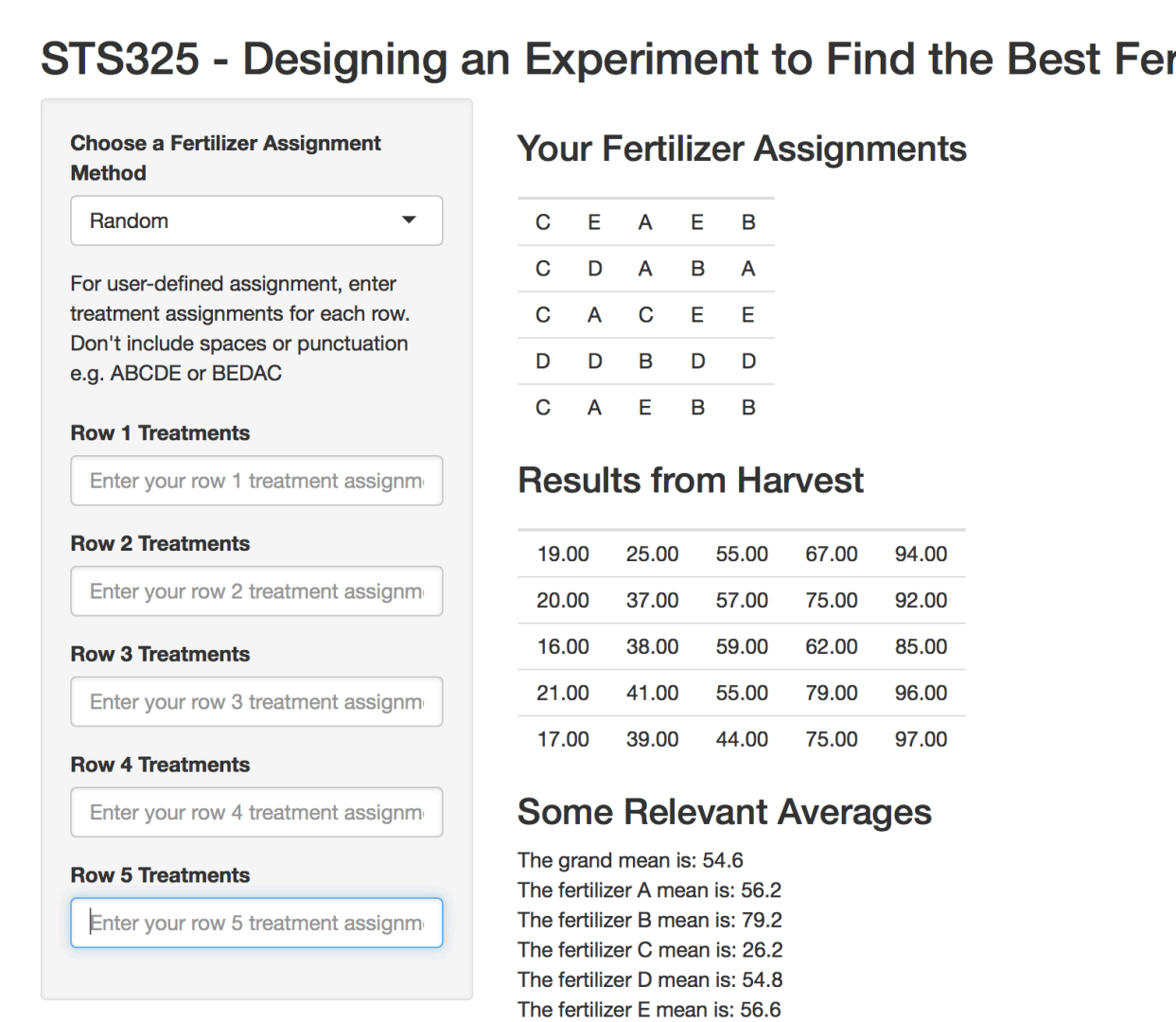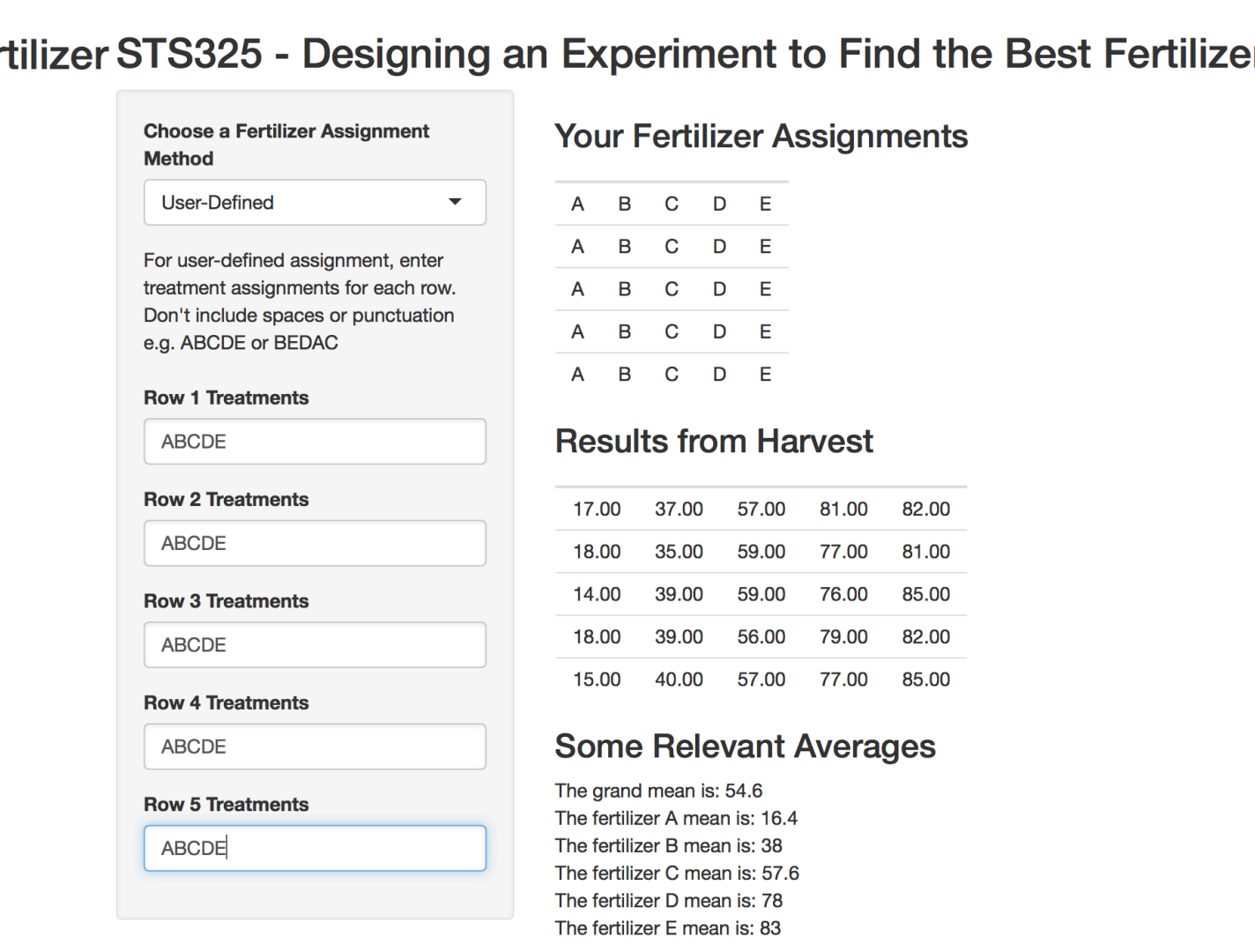
Takeaways / Added Bonuses

- Randomness means not everyone reaches the same answer. We can discuss why there may still be a "best" option.

- Some methods may work better in one situation and not in another. Both apps could be extended to create different versions of the field to explore this.

- If students know R, they can run these apps directly in R Studio. If not, you can give them a URL to visit.

- Some students get excited when they realize the teacher made the app they're using. Encourage them to learn more / create their own.

Cautions

If an app is computationally intensive (lots of re-randomization, etc.) it can crash when many students use it at once. Be flexible and rewrite code when possible. I usually tell students we're trying something new and to let me know how it goes. They are understanding if it doesn't work perfectly.

Resources

NCSSM Statistics Institute Resources
https://www.ncssm.edu/residential-mathematics/statistics-institutes

Apps I've created for courses
https://github.com/vank-stats/Teaching-Apps

Learning R
https://swirlstats.com/students.html

Learning Shiny
https://shiny.rstudio.com/tutorial/

Special Thanks To Dr. Laura Taylor (Elon University) who provided me with these two activities initially.