Authenticity, Accessibility, and Universal Design:

A Qualitative Case Study in the Statistics Classroom

Trevor Presgrave

University of Cincinnati

Making classroom activities more authentic, closer to real life applications, while keeping them accessible to students is a challenge. In this paper, I present a case study based on my experiences with incorporating more authentic projects into my introductory statistics course. The paper highlights some of the challenges and conflicts I faced as well as how I was able to implement a solution. In this case, the solution took the form of an interactive website that allowed students focus on the parts of the project that were relevant to their professional lives, while suppressing details that were not relevant to the course or their professional careers. This case study uses qualitative data, describing the changes in questions students asked about the project when they were left to code software commands manually versus when they had a website to assist them.

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One semester, I was both working on a research project and teaching a statistics course. For my research project, I was dealing with a large data set and using statistical software to handle the busy work of calculation while I dealt with the interpretation of the results. By contrast, with the statistics text I was using in my course, I was preparing students to work with very small data sets and asking them to perform the calculations using tables and hand calculators. I realized that what was going on with the textbook's homework was not really an authentic activity. The students in my statistics class were largely majors in nursing, psychology, education, and sociology, and while many of them might have had a need for statistical analysis, none of their fields of choice require researchers to use hand calculators and printed tables to perform analysis. The kinds of tasks I had the students working on in class and the ones they would face in their professional lives were not well matched.

Background Literature

Authentic learning occurs when students are involved with a task that "involves real-world problems that mimic the work of professionals in the discipline" (Rule, 2006). Authentic learning, is import as it improves student engagement and gives relevance to the material being taught (Pearce, 2016). Successfully building these real-world learning connections has also been shown to be a predictor of student achievement (Newmann & Associates, 1996). Researchers who study authentic assessment and learning have stated the importance of making certain that students are being tested in situations that mimic their future real-world settings to ensure students will develop the professional competencies needed to succeed (Gulikers, Bastiaens, & Kirschner, 2004).

However, for authentic assessment and learning to occur, the students must start off with an authentic task (Herrington & Herrington, 1998; Newmann, 1997; Wiggins, 1993). An authentic task is "a problem task that confronts students with activities that are also carried out in professional practice" (Gulikers, Bastiaens, & Kirschner, 2004, p. 71) and should require students to integrate prior knowledge and skills (Gulikers, Bastiaens, & Kirschner, 2004). Rule (2006) used mathematics as an example of creating authentic tasks, saying an authentic task in mathematics should use complex and realistic data and require and activate a wide range of background knowledge.

Creating an Authentic Task

Since the lack of statistical software was causing the misalignment between what the students were doing in class and what they would do professionally, the adoption of statistical software seemed to be the most direct solution. Students and faculty in many fields make use of statistical software when conducting research, so getting the students in my class to use statistical software and interpret the associated results would be an authentic task. However, when the time came to choose the software, another question arose: which software analysis package should I choose? In keeping with the goal of having students engage in an authentic task, the ideal software package is one that they could encounter in their professional careers. I considered several of the most popular software packages: SAS, Stata, Minitab, SPSS, and R. After much consideration, I decided to use R because it was the only major statistical software package that was available to students at no cost. I could not justify requiring students to make more trips to campus to use software that was only available in computer labs or asking them to spend money beyond that which they had spent on the textbook and the online homework system when there was a free, professional grade, option available. I saw R as a way of increasing the authenticity of their tasks without putting in place even more financial barriers.

About R

R is an open-source free software system for data analysis that was released under the GNU General Public License and is available for Windows, Mac, and Linux operating systems (The R Foundation, 2017). R users interact with a command line user interface (CLUI), rather than the button-and-menu-based graphical user interface that is common today. The R CLUI requires the user to know and type in commands using very specific syntax guidelines (Ihaka & Gentleman, 1996) to get the software to perform actions. Using the CLUI would give students exposure to, what for many of them, would be a new type of computer interface. However, using the CLUI would also require me to expand the scope of the class to include some very basic R programming. Since my concern at the time was with increasing authenticity, I decided to have students use the CLUI, as that most closely resembled real world tasks.

Case Study Background

This case study documents two separate attempts to incorporate R in the statistics classroom. The first attempt took place over two separate sections of an introductory freshman-level statistics class. One entailed a full-term section, and the other was an accelerated half-semester summer section. The second attempt also took place over two separate sections of the same introductory statistics class: one full-semester section and one accelerated half-semester summer section. They were taught at a large public university’s regional campus. The number of students in each case ranged from 18 to 25, with the majority of students being freshmen and sophomores. However, a few juniors and seniors were enrolled. The students represented a variety of majors, but nursing was the most highly represented one in the sample.

R in the Classroom: Attempt #1

Method

To introduce R to the students, I used the approach that my professors had used to teach me R. I presented the students with a few sample problems, along with the R code that they needed to enter into the CLUI to solve them. The homework entailed having the students solve similar problems with slight changes to the examples needed each time. Figure 1 shows an example problem and solution that would be given to students as part of their course notes, and Figure 2 shows the corrosponding homework problem that they would be expected to solve on their own.

Example Problem:

After weighing 184 widgets you found the average widget weighed 17.2lbs with a standard deviation of 38.5lbs. Construct a 95% confidence interval for the true weight of a widget.

Example Solution:

```
17.2-qt((1-(1-0.95)/2),df=183)*38.5/sqrt(183)
17.2+qt((1-(1-0.95)/2),df=183)*38.5/sqrt(183)
```

Figure 1. Sample Notes.

Example Homework Problem:

After testing 200 engine belts you found the average lifetime of an engine belt was 3.176 years with a standard deviation of 0.428 years. Construct a 90% confidence interval for the true lifetime of an engine belt.

Figure 2. Sample Homework Question.

Results

While this learing approach worked for some students, many others had problems succesfully modifying the code. They were not used to having to have precise typing skills. If a comma was misplaced in an English paper, the paper was still generally understandable to whoever was reading it. However, if a comma was misplaced in a piece of R code, the entire code became unrunnable. This proved frustrating for the students and ran counter to UDL assessment guidelines (Gordon, Meyer, & Rose, 2016) as a skill I was not testing (R coding ability) was interfering with a skill I was testing (the ability to interpret statistical results). In fact, the majority of questions I received about the project took the form, “Why doesn’t my code work?” Getting the R code to work was not one of the learning objectives of the class, nor was it something to which I wanted to devote a large proportion of class time. Nevertheless, I felt it was essential to include because it made the tasks more authentic. I did, however, start to think about ways to allow students to focus on certain parts of the task, such as choosing the appropriate statistical test and interpretting computer output, rather than focusing on coding. I saw selecting the correct statistical method and interpretting computer output as the most important parts of an authentic task because those two things are required not only for those conducting research, but also for those that wish to understand and evaluate the research of others.

R in the Classroom: Attempt #2

Method

The main failure in my first attempt to implement R in the classroom was the amount of student effort and focus that was misdirected toward the intricacies of writing commands in the R language. I needed a way for students to generate R commands without having to worry about accidently adding an extra comma or missing parentheses so that they could focus on deciding what kind of analysis needed to be done and how to interpret the results. There are already some tools that address this problem, for instance, R Commander (http://www.rcommander.com). However, this tool was not an ideal solution either. Students with limited technological literacy skills could experience difficulty installing it, and the variety of functions it allowed a user to do could be overwhemling to those who were not already familiar with statistics. I needed something that was like R Commander but had a more limited scope. However, nothing like that existed then, so I built it.

I developed a website called R-Face using basic HTML and JavaScript to provide students with a Graphical User Interface (GUI). While R was capable of a vast array of statistical calculations, the website I created only assisted students with calculations that they would encounter in a freshman-level statistics course (see Figure 3). This more limited set of features was designed to reduce the user's cognitive load, thus improving usability (Molich & Nielsen, 1990; Shneiderman & Plaisant, 2010).

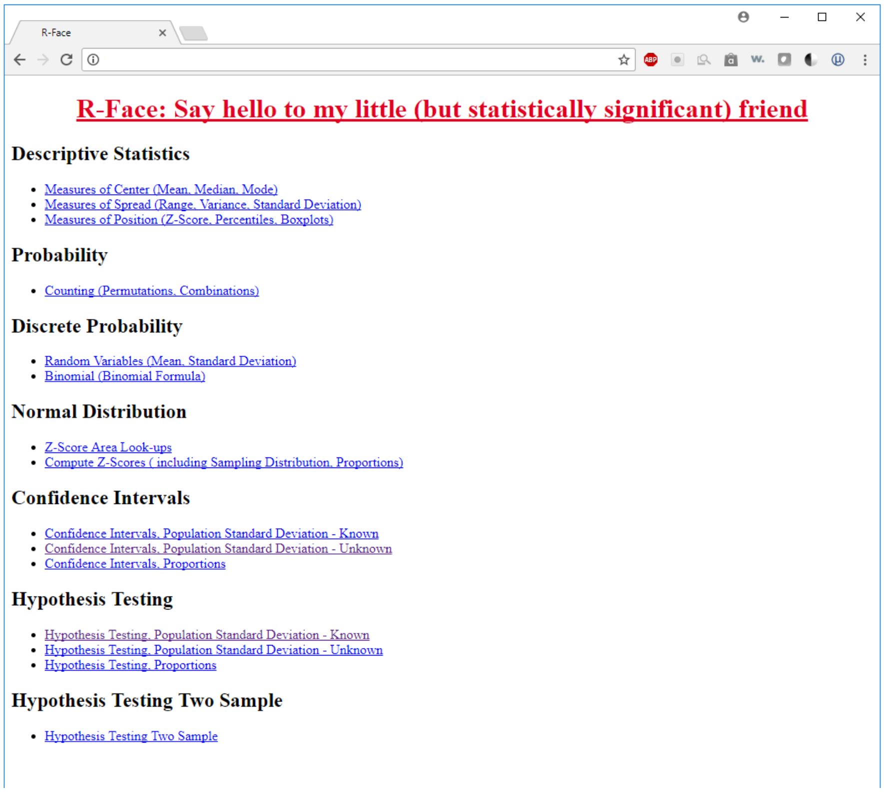

Figure 3. R-Face Main Menu.

I limited the scope of the topics to prevent the choices from overwhelming the students. The content areas on the website corresponded to the topics in most introductory undergraduate statistics books. Each topic was intentionally broken off onto its own webpage, allowing instructors the flexibility to make an assignment as easy or as challenging as they wanted. A problem given to students could be explicitly included in a direct link to the relevant topic or the instructor could leave it to the students to identify what kind of problem they had been presented with and which link they should follow as part of the problem-solving process. Once a student selected a topic of interest, he or she was presented with a series of prompts to help construct the needed R commands (Figure 4). After the student typed in the information requested (Figure 5), clicking the “Generate R Code” button would create the commands needed to solve the problem (see Figure 6). Once the commands had been generated, the student simply needed to copy, paste, and run them in the R CLUI to get an answer.

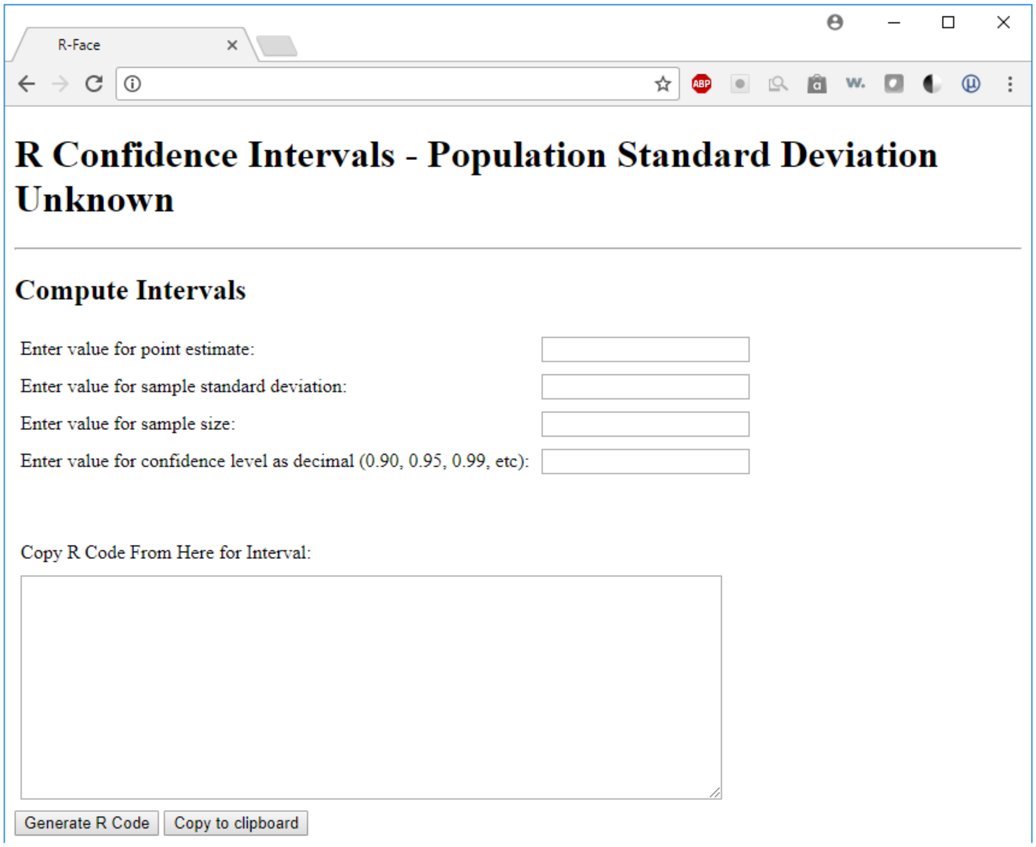

Figure 4. Sample R-Face Prompt.

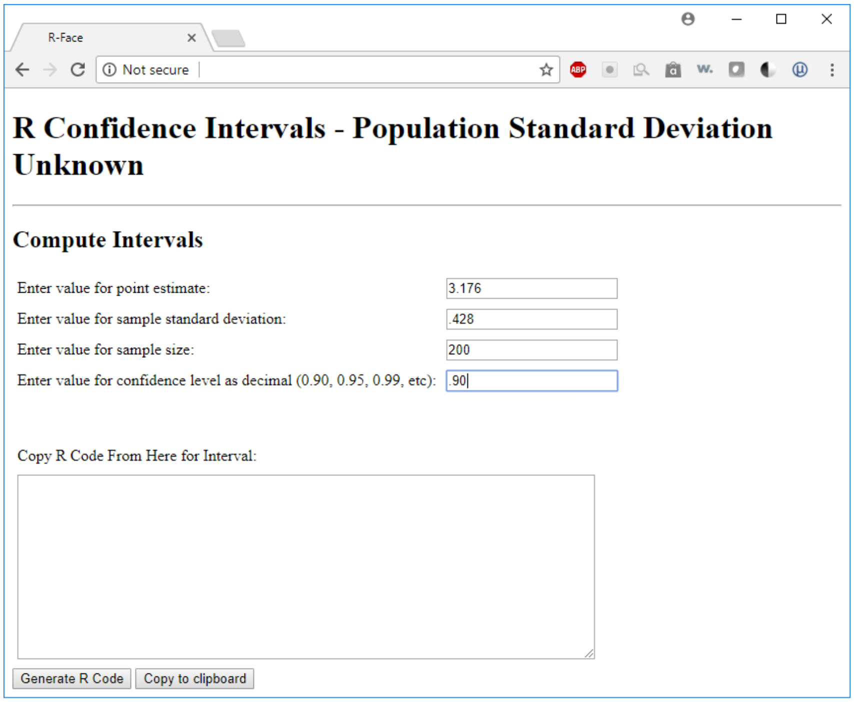

Figure 5. Prompts Filled in.

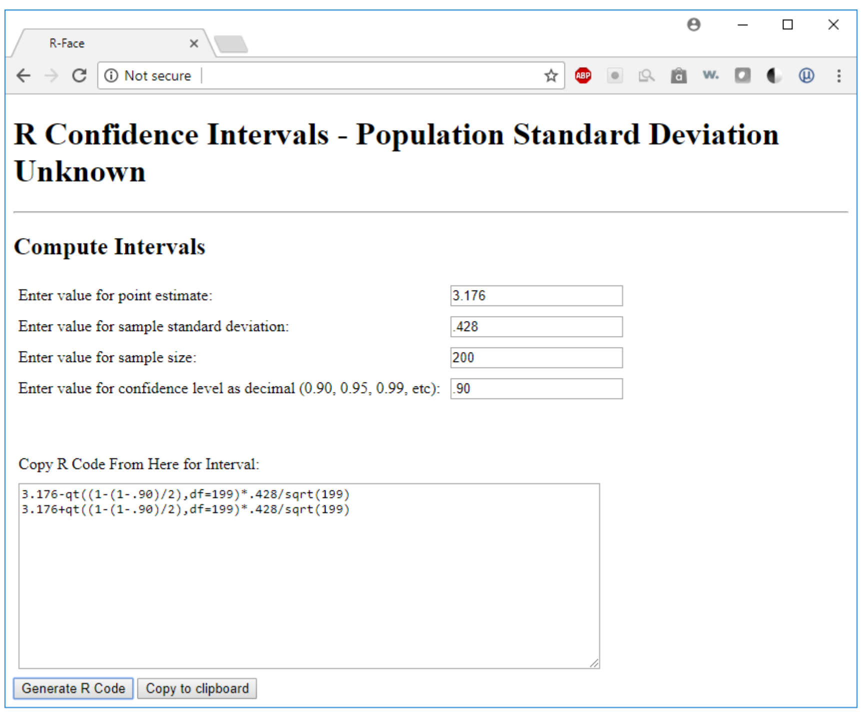

Figure 6. R Commands Generated.

Results

After introducing the website to the class, I once again provided the students with a set of homework problems to solve using R. This time, the questions I received about homework were different. The students asked questions like "Should question #7 be solved as a permutation or combination?" and "The p = 0.04812 means we reject the null hypothesis, right?" These questions were much more in line with the content of the course than the previous ones. The students were no longer focused on the details of coding R commands for the CLUI but on the kinds of problems they were dealing with and what the numerical results would mean translated into English. This was much closer to the kinds of challenges the students would face in their professional lives: having collected data, they would need to decide what kind of statistical method to use to analyze the data, and, once the computer had analyzed the data, they would still need to be able to interpret those results. This second attempt created a more authentic task for the students without testing them on skills that were extraneous to the learning objectives of the course.

Reflections and Conclusion

My main goal in writing this paper was to share with others the conflict that we, as educators, sometimes face when trying to follow best practices and recommendations from a variety of sources. Researchers of authentic assessment and learning focus on the importance of reduced, or even no instructor support (Gulikers, Bastiaens, & Kirschner, 2004). Researchers in UDL have stated the importance of minimizing distractions, supporting the decoding of mathematical symbols, and providing graduated levels of support (Gordon , Meyer, & Rose, 2016). While each research stream makes valid points individually, trying to combine them in the classroom can give rise to some conflicts. Providing simplified versions of technology jargon or mathematical notation may be helpful. However, in many professional disciplines, such difficult terms and notations are present. Likewise, writing a multi-page problem description for a case study may be authentic, but it may purposefully include extraneous information.

It is important for an instructor to balance these sometimes-conflicting approaches to designing course content. In the beginning of my course, students only did problems from the online textbook. These problems included text and images, provided hints when needed, and were short, clear, and unambiguous. From a UDL standpoint, the textbook problems were excellent. However, the approach they required students to use, which entailed looking up values from printed tables and summing and dividing numbers by hand, was not at all what the students would face in their professional lives. I had assignments that fully complied with UDL but were not at all authentic. In my first attempt to incorporate R in the classroom, I allowed the pendulum to swing too far in the opposite direction. The students were facing realistic problems, but they were struggling with technical issues not included in the student learning objectives for the course, and it was slowing them down. It wasn't until I constructed the R-Face website that I started to find a balance between providing students with some level of support and exposing them to tasks that resembled what they might encounter in their professional lives.

I do not mean to suggest that all faculty should become software developers, but I wanted to share my experience with the iterative process of trying to balance the demands between sometimes opposing design principles. This is still an ongoing process. I am not certain that I have achieved the "perfect balance" in the course yet, but I have gotten closer than I initially was. One key principle shown in this paper toward designing authentic assessment is to keep in mind how we, as experienced professionals in our fields, would solve a problem. Is the way we would approach the problem different from the way we teach students to do it? If so, we need to be able to articulate why we are not teaching what the students will be doing when they apply the knowledge from the course in their professional lives. An instructor needs to consider how to teach the basics skills of a discipline in a way that will also allow them to transfer that knowledge to the contexts in which they will use this knowledge outside of the classroom. It was in asking myself how to bridge the gap between the classroom and non-academic applications that I realized the innovation discussed in this paper.

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