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When Technology Is Too Hot, Too Cold Or Just Right

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ABSTRACT

Many instructors acknowledge the importance of quantitative literacy in non-STEM fields and may themselves use advanced tools for data analysis, statistics and visualization. But how, if at all, does an instructor introduce quantitative methods into the classroom without overwhelming and disengaging students who may have been drawn to the field precisely because it has not traditionally required any skill or interest in science, technology, engineering or math? I present a model of iterative assignment design illustrated by the evolution of a phonetic exercise in which students are asked to measure vowels from their own speech and to plot their measurements on a graph in order to re-create the standard organization of vowel sounds found in linguistics textbooks. The different iterations involved varying degrees of technology (from low-tech pencil-and-paper to high-tech computing environment) and technological support and are evaluated with respect to NICHE best practices. The most recent iteration finds a compromise in a simple web app driven by the powerful R statistical computing environment.

Keywords: Digital Humanities, Open Source, Personalized Learning

THE PROBLEM

The notion of quantitative literacy describes an ability and level of comfort with numerical data, including charts, graphs and other visualizations of numerical data (Association of American Colleges and Universities, 2009), a foundational fluency in STEM and social science fields, but of increasing importance in the humanities and, indeed, a prerequisite for most scholarship in the digital humanities. Most, if not all, undergraduate general education incorporates some degree of quantitative literacy instruction, such as an introductory-level course in mathematics. For students majoring in a humanities discipline, general education STEM courses may be the only ones they take, however. A survey of 2008 graduates by the National Center for Education Statistics (Cataldi et al., 2011) reveals that “humanities majors tended to earn fewer STEM credits than STEM majors earned humanities credits” (American Academy of Arts & Sciences, 2014, para. 2). Humanities majors had a median number of 11 STEM credits out of 127 total. It’s also unclear how effectively those STEM courses, so removed in subject matter from students’ major, teach quantitative literacy. As Richardson and McCallum (2003, p. 102) argue, “quantitative literacy is not simply a matter of knowing how to do the mathematics but also requires the ability to wed mathematics to context.”

It is perhaps unsurprising, then, that digital humanities is so underrepresented in the undergraduate classroom. Any faculty outside of a math department who incorporate quantitative literacy instruction are already “lone crusaders”, hampered in many cases by “administrations that depend on student credit hours as the coin of the realm” or by “student evaluations that can tend to favor less quantitatively challenging courses” (Richardson and McCallum, 2003, p.105). Scholars in the digital humanities also note that the reward structure heavily favors research over pedagogy (Brier, 2012; Hirsch, 2012; Waltzer, 2012). “Research,” writes Hirsch, “remains the principal vehicle for professional nobility and mobility in the digital humanities” (p. 5). Brier suggests that “teaching and learning are something of an afterthought for many DHers” (p. 391).

The picture appears to be that students in non-STEM majors are less inclined to enroll in and less inclined to give favorable evaluations of courses with a quantitative component. In an academic culture that privileges research ahead of teaching, and assesses teaching largely in terms of student evaluations, these are serious disincentives for an individual instructor or academic department to bring quantitative literacy instruction into the classroom.

Compounding the problem, quantitative literacy frequently requires a corresponding computational literacy. Researchers do not perform statistical analysis

or produce visualizations of numerical data by hand. At a minimum, most quantitative research requires computer programs with a graphical user interface (GUI) and, for more sophisticated analysis, a command-line. In my own field, linguistics, several textbooks have been published in the last decade about quantitative analysis (Baayen et al., 2008; Johnson, 2011; Gries, 2013; Levshina, 2015; Smith et al., 2016) and all of them have required readers to also learn the command-line environment and programming language R (R Core Team, 2016).

Computational literacy instruction is equally challenging, particularly for a student population dominated by millennials. A hallmark of millennials, born roughly between 1982 and 2002, is that they have grown up with computers and computer technology: they are “digital natives” (Prensky, 2001; McAlister, 2009). In contrast to the popular image of millennials, studies by Eszter Hargittai and Brayden King reveal “a stratified landscape in which some, mostly privileged, young people use their skills constructively, while others lack even basic Internet knowledge” (O’Neil, 2014, p. 5).

My contribution explores this challenge: mitigating the barrier of technology for the purpose of quantitative literacy instruction. The context is a particular assignment in an upper-year linguistics class which required students to use acoustic measurements of their own vowels to create a visualization. Over the course of several semesters, I made incremental changes to the assignment which in hindsight turned out to follow a trajectory of increasing technological sophistication, from low-tech (pencil-and-paper) to medium-tech (Microsoft Excel) to high-tech (R). In the most recent iteration of the assignment, I explored a technological compromise: presenting students with a custom Web 2.0 app, which is nonetheless powered by R behind the scenes.

The revisions, described below, arose organically in the course of teaching, in response to formal and informal student feedback, and my own desire to provide students more authentic learning. It was not my intention to pursue these revisions as a research study; however, it became clear that other instructors may benefit from my experience. I present my iterative design process as a model for instructors in order to revise the quantitative literacy component to meet student need. In particular, I will discuss my revisions in the context of Best Practices for Quantitative Reasoning Instruction published by the Numeracy Infusion Course for Higher Education (NICHE), including:

- real world applications and active learning, including discovery methods;
- pairing QR instruction with writing and critical reading;
- using technology, including computers;
- collaborative instruction and group work;
- pedagogy that is sensitive to differences in students’ culture and learning styles;
- and scaffolding the learning process and providing rich feedback and opportunities for revision.

BACKGROUND

For nearly all undergraduate students, linguistics may be described as a discovery major. Even among academics, the discipline of linguistics is often little known. Although many universities have a separate department of linguistics, people researching language in higher education may also be found in departments of anthropology, classics, computer science, education, English, law, philosophy, psychology, speech language pathology, sociology and of specific languages, to name a few.

There are several reasons for this fragmented distribution, not least of which is that the breadth and depth of linguistic subfields reflects the considerable complexity of human language. Many aspects of language are regular and rule-governed, like the laws of physics or the functions of biological systems. Other aspects of language are, by contrast, influenced by human culture. For this reason, linguistics departments may be variously housed in colleges of humanities, social sciences, cognitive sciences, behavioral sciences or physical sciences.

Students who discover linguistics in the context of the humanities, in my experience, most typically fit the profile of the non-STEM major. Some students are surprised to find that linguists approach language from a scientific perspective (i.e., making and testing hypotheses about language) rather than a purely humanistic or literary perspective. Students find comfort, however, in that the required courses of a traditional linguistics degree—e.g. syntax, phonology and semantics—are heavily influenced by the scientific yet introspective methods of Noam Chomsky and subsequent generative linguists and do not require a substantive quantitative literacy. Chomsky (1969) famously pronounced that experimental laboratory methodologies, of the type commonly used in psychology, were “a waste of time and energy” (p. 81).

By the 1990s, however, several research cultures emerged which valued both the introspective methods due to Chomsky and quantitative methodologies (e.g., Laboratory Phonology: Cohn and Fougeron, 2012; Kingston and Beckman, 1990; Experimental Syntax: Bard et al., 1996; Keller, 1998; Schütze, 1996; Wayne, 1997). In most cases, however, quantitative methods have not found their way into undergraduate textbooks and classrooms, particularly not at the introductory levels. Mirroring the situation in the digital humanities, one often finds a disconnect between the breadth and depth of quantitative methods employed by linguistics faculty in their research and the dearth or absence of these same quantitative methods in their teaching.

The subfield of phonetics—which studies the physical aspects of speech, including speech articulation, perception and acoustics—is to some extent the exception. Phoneticians have a history as early adopters of technology, using tools from medicine and physics as early as the nineteenth century (Loakes, 2013; MacMahon, 2013). Praat (Boersma and Weenink, 2016), the widely adopted acoustic analysis software which is used in the assignment discussed here, has been available for free on Windows, Unix and Macintosh platforms for more than two decades. The proceedings of the Phonetics Teaching and Learning Conference, a biennial conference since 2005, is dominated by the use of quantitative and computational methods (University College London, Psychology and Language Sciences, 2005).

VISUALIZING VOWELS ASSIGNMENT

The visualizing vowels assignment is one of a series of laboratory assignments in an introductory undergraduate phonetics class. As is standard, the course introduces students to the basic articulatory, acoustic and perceptual properties of speech sounds, as well as the transcription of speech using the the International Phonetic Alphabet (IPA) (International Phonetic Association, 2015). The visualizing vowels assignments encourages students to integrate their learning of articulation and acoustics by uncovering an important relationship between the textbook classification of vowel sounds according to articulation on the one hand and two particular acoustic measurements on the other.

The IPA organizes vowels according to articulatory properties, including tongue height and tongue advancement (Figure 1). The organization of the chart corresponds, roughly, to the way that sounds are produced in the mouth of a speaker. Symbols that appear towards the top of the chart represent vowels that are

made with a higher tongue position; symbols that appear towards the bottom of the chart represent vowels that are made with a lower tongue position. Symbols that appear towards the left of the chart represent vowels that are made with the tongue in a more front position; symbols that appear towards the back of the chart are made with the tongue in a more back position.

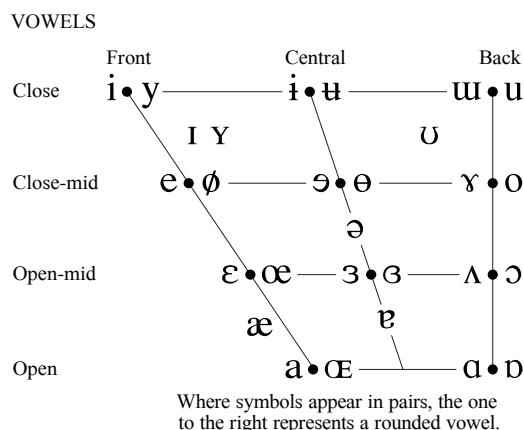


Figure 1. Vowel section of IPA Chart.¹

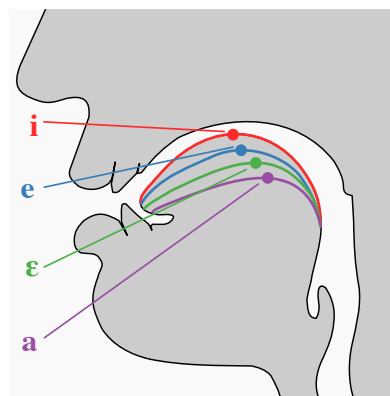


Figure 2. Idealized tongue position of four front vowels, from highest to lowest: [i] as in *heed*; [e] as in *hate*; [ɛ] in *head*; and [a] in *hod*.²

Although the correspondence between tongue position and position on the IPA chart is roughly correct, the articulatory differences between vowels is subtle—much more so than between consonants—and students cannot reliably use their own mouths to identify or memorize the classification of sounds by tongue height

¹ <http://www.internationalphoneticassociation.org/content/ipa-chart>, available under a Creative Commons Attribution-Sharealike 3.0 Unported License. Copyright © 2015 International Phonetic Association.

² From “Cardinal vowel tongue position-front,” by Badseed, 2008, https://en.wikipedia.org/wiki/International_Phonetic_Alphabet_-_media/File:Cardinal_vowel_tongue_position-front.svg. Creative Commons 4.

and advancement. (The interested reader is invited to produce the vowels illustrated in Figure 2). Indeed, most phonetic studies of vowels use acoustic measures, which mirror the space of the vowel chart more closely and, happily, do not require invasive methods like MRI or ultrasound. It turns out that, for any vowel, there are two specific acoustic measurements (first formant, F1, and second formant, F2) that can be used to situate a vowel on the chart: F1 is inversely correlated with vowel height and F2 is correlated with vowel advancement (cf. Figure 3).

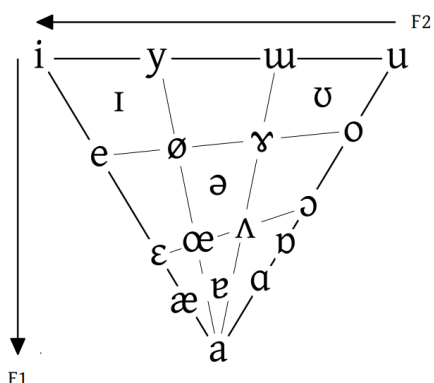


Figure 3. Idealized IPA vowels plotted according to first formant (F1) and second formant (F2).³

In the assignment, students are asked, first, to use the Praat software (Boersma and Weenink, 2016) to record themselves producing the vowels of English and for each vowel to measure F1 and F2. This part of the assignment remained the same across different iterations. Second, students were asked to use the formant measurements to create a plot of their vowels. At this stage in the course, students have already practiced using Praat for making and manipulating speech recordings; however, they are identifying and measuring formants for the first time. An important secondary motivation for plotting the vowels, in addition to the initial motivation of discovering the relationship between formants and the classification of vowel sounds, is to provide some context for the measurements. Students are not familiar with units of measurement like milliseconds (ms) and Hertz (Hz) from daily life. They lack any expectations for what constitutes a likely value for a formant, what range of variation (for a given vowel or speaker) is likely or what level of precision is required (e.g., a difference of 1 Hz is unlikely to be significant).

³ From “Vowel triangle, cardinal vowels,” by Kwamikagami, 2015, https://upload.wikimedia.org/wikipedia/en/archive/8/87/20151004010013%21Vowel_triangle,_cardinal_vowels.png. Creative Commons 3.

Seeing formant measurements on a plot that resembles the familiar vowel chart from the textbook provides students with some context to decide whether their measurements are reasonable, or should be revisited. Lastly, students are asked to compare their vowel plot with the plots of one or more classmates. This comparison provides students additional feedback on the success of their measurements and also lays the foundation for critical analysis of what is invariant about vowel quality and what is variable.

The class meets for two 75 minute sessions each week in a 25 seat computer lab. One of the weekly meetings is devoted strictly to laboratory assignments such as this one, with a brief introduction by the instructor and followed by hands-on support from the instructor and peers. Assignment instructions appear as a “quiz” in the learning management system (Canvas) with individual questions that require students to write comments and/or upload files. The assignment is not due until the following week and most students continue work on it outside of class: some students make use of a staffed computer laboratory available to students, while others choose to download Praat to a personal machine.

LOW TECH

The oldest version of the visualizing vowels assignment, to the best of my knowledge, comes from the authoritative textbook *A Course in Phonetics* by the late Peter Ladefoged, first published in 1975 and now in its 7th edition (Ladefoged and Johnson, 2015). The textbook invites students to measure the F1 and F2 values of the author’s vowels from a spectrogram printed in the textbook and to plot them on a blank chart provided in the appendix or (in later versions) the companion website (Figure 4). In the first iteration of this assignment, I required students to use the same blank chart that appears in *A Course in Phonetics* to plot their vowels using pencil and paper.

The premise of the assignment, which is true for all four iterations discussed here, is that students discover the relationship between formant values and vowel position by engaging in active learning rather than being told about the relationship in a textbook or lecture. As discussed above, my subsequent revisions of this assignment were not initially intended for scholarly study and so I cannot report on individual student work or comments. Anecdotally, however, I can report that many students later cited this assignment as among the most memorable, because measuring the formants was both hands-on and personal.

The task of plotting the vowels with pencil and paper, however, is inauthentic. Contemporary phoneticians do not plot vowels by hand. Although students did not complain about this lack of authenticity, I as the instructor regretted the missed opportunity for professionalization.

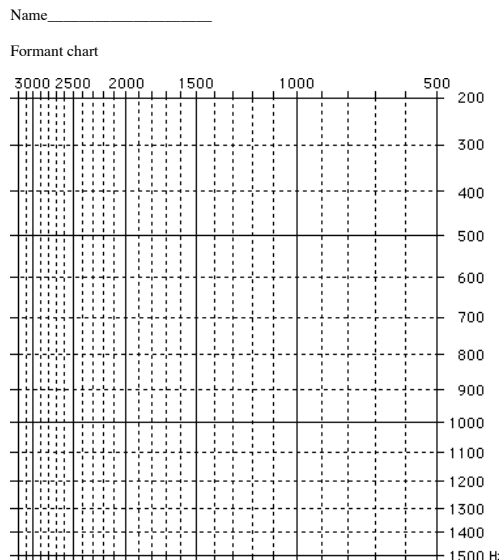


Figure 4. Blank chart provided at the companion website for A Course in Phonetics (UC Berkely Linguistics Department, 2015).

Although more literally hands-on and tactile than digital methods, the analog pencil-and-paper method is also in strange juxtaposition with the high-tech acoustic analysis and the learning management system. Some students submitted their hand-annotated plots as scanned images, while others felt more comfortable staying digital and annotated the blank PDF using an image editing software.

The pencil-and-paper plotting also limited opportunities for collaboration. It is possible to plot two sets of vowels (the student's and a classmate's) on the same chart; however, the chart quickly becomes crowded if the two have similar vocal tracts, and plotting multiple students' vowels is a mess. A student then has little to contextualize his or her vowels, save those of another student, whose values may also be in doubt, and the organization of the official IPA chart itself. Since plotting a classmate's vowel was the final task, and most students were completing the assignment outside of class, the paper plot was also an obstacle for data-sharing.

Since plotting the vowels was a source of feedback to students on the quality of their acoustic

measurements, I gave students the opportunity to submit a revised plot. Few students elected to submit a revision, however. In this iteration of the assignment, revising meant recreating the plot from scratch, even if revising a single data point. I speculated that this was a disincentive for students to attempt a revision. I also required students to write critically about their plot by comparing it with their classmate's plot and with the standard IPA vowel chart and by advancing hypotheses about the source of variation (e.g., differing vocal tracts, dialect, human or computer error). Possibly for the same reason, few students advanced human error as a hypothesis. With only one other speaker to compare with, it was also not possible for students to test, even preliminarily, whether dialect or anatomy contributed to an observed variation.

MEDIUM TECH

In order to make the assignment fully digital, I introduced the use of Microsoft Excel for the next iteration of the assignment. Although there is no online repository of phonetics assignments, a brief search of the web reveals two approaches to the use of Excel for plotting vowels. The first approach is to provide written or video instructions to students for creating the plot from scratch (e.g., de Jong, 2016; Russell and Russell, 2012); the second approach is to provide a template to students for which they only need to supply the measurements (e.g., Moore, 2014). I choose the second approach, modifying an existing Excel template created by A. Raymond Elliott for the 2014 Collaborative Language (CoLang) Research conference (Elliott, 2016). The modified version with hypothetical student data is shown in Figure 5.

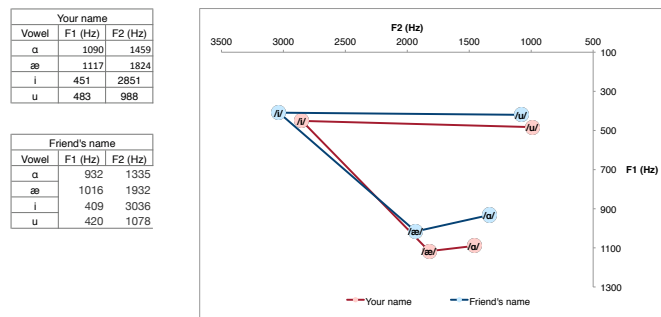


Figure 5. Modified version of A. Raymond Elliot's (2016) Excel template with hypothetical student data.

Although developing technological literacy is a worthy goal, this assignment already required students to use other technology for the first time (i.e., the formant-related functionality in Praat) and I wanted the emphasis

in the plotting part of the assignment to remain on the relationship between formants and the vowel chart. Despite their stereotype as “digital natives”, many millennial students have low literacy with Microsoft Excel (e.g., Shannon, 2008; Shannon et al., 2006) and, anecdotally, may find using the tool more stressful than fun. The template allows students to focus on the visual representation of the vowel space and not be distracted by the mechanical particulars of moving and scaling axes, labeling individual points, etc.

The corollary is that students have little control beyond manipulation of formant values. The rigidity of the template and idiosyncrasies of Excel also discourages the instructor from modifying the template: changes such as adding vowels, representing them dynamically (with start point and end point) or allowing for additional recordings or speakers requires a non-trivial amount of time and effort.

In that sense, while use of Excel provided the same opportunity for active learning and discovery, the task remained inauthentic. Visualizations of vowel space published in the phonetics literature are not typically produced in Excel. While the point-and-click graphical user interface is appealing for the casual user, researchers tend to prefer the power and versatility of a command-line tool like MATLAB or R, discussed below.

Like the pencil-and-paper method, plotting in Excel also did not lend itself to revision or collaboration, particularly when combined. The template I used did have fields for a second speaker, but it is necessary to enter the second speaker’s values manually. Unlike revising on paper, revising in Excel simply meant entering new numeric data. Communicating this revision for collaboration, however, remained awkward. The Excel file that a student submits has two plots: one of her own vowels and one from a classmate. If the student compares her plot with a classmate’s plot and then subsequently revises some of her measurements after the in-class time has ended, she must then communicate the changes to her classmate in order for the classmate to revise her own Excel file. The extra effort involved, although not insurmountable, is a clear disincentive and, as with the pencil-and-paper iteration, students mostly did not make revisions. An online solution, such as Google Sheets, could mitigate this considerably; however, many of the required functionalities are not yet available.

With these limitations on revision and collaboration, the opportunities for critical writing were similarly

limited. Where students’ plots differed from the standard textbook plot or from their classmate’s plot, they offered fairly general hypotheses about the effect of accents and physiology for which they had little evidence.

HIGH TECH

As noted, the most authentic plotting task would require students to plot their vowels using a command-line tool like R. The power and flexibility of the R tool is invaluable for a full-time researcher. Complex, reproducible, publication-quality visualizations can be achieved with a single line of code, and can be easily repeated for new data without the mousing and clicking through a cascade of menus that is required of GUI-based environments. The program is free, open-source, runs on Windows, Mac or Linux and has a large community of users who contribute cutting edge packages. These packages include phonR (McCloy, 2015) which offers sophisticated vowel normalization and plotting functions.

For a less sophisticated user, the benefits of R may not be outweighed by the steep learning curve. Some basic understanding of a command-line interface and principles of programming are required. While this level of computational literacy can and should be incorporated into a non-STEM curriculum, it does not always make sense at the level of an individual course or assignment where the development of computational literacy may compete with quantitative literacy and discipline-specific pedagogical goals. For students who may already be struggling with the more advanced features of Excel, the R environment can be needlessly overwhelming and frustrating. In the short term at least, the technology gets in the way.

My departmental colleagues who sometimes teach courses that emphasize computational skills report that this particular constituency of students typically struggles to get comfortable with the command-line. Not unlike the creation of a template for Excel, however, I pursued a similar work-around for R. I required students to submit their measurements in a specific format, in this case a .csv or “comma-separated values” file, which students could open in Excel and which I could read in to R.

On my end, this allowed increased power and flexibility to manipulate student data, such as plotting all students’ vowels on the same figure or automating the task of identifying vowel measurements which are obvious outliers. On the student’s end, however, the process was a “black box”: mysterious, opaque and no longer interactive. I was able to generate a single plot

with data from multiple students, plots with transformed axes (e.g., barks or ERB units of measurement instead of Hz), which provided much richer sources of data for students to write about. However, these choices—which groups of students to include, which units, etc.—are driven by me or in a few cases the class as a whole, rather than individual students as part of their own exploration of the data.

This iteration also required more instructor time to prepare and facilitate. Given the effort involved on my side, I regretfully did not offer students the opportunity to revise their measurements.

2.0 TECH

In the most recent iteration of the assignment, I made use of the R package shiny (Chang et al., 2016), which allows one to build interactive web applications using only R (although advanced users can write directly in HTML, CSS or Javascript for more flexibility). In one part of the R code, one writes user interface (UI) functions which are HTML wrappers. Input functions include buttons, checkboxes, sliders and text and numeric input. Output functions may be text or graphics, created as usual in R but with values dependent on user input.

I used the shiny and phonR packages together to create an interactive web app for students (Figure 6). Students enter numeric values, adjust them up or down with arrow bars and observe changes to the plot in real time. I also made it possible for students to share their data with everyone in the class, allowing students to compare their vowels to those of many other students and to explore hypotheses for possible variation by filter results by gender, language background and other parameters.

The task in this iteration may be viewed similarly inauthentic as in previous iterations, since it differs from the typical procedure followed by a researcher; however, the task more closely mimics an ideal or target procedure: all learners, whether students or professional researchers benefit from interactive, graphical exploration of their data. Thomas and Solomon (2014), for example, involved undergraduate students in the development of a digital humanities app for visualizing social networks of knowledge. They found that “screwing around” (cf. Ramsay, 2014) offered similar benefits to students and researchers for discovery.

Since the vowel visualization app was hosted online, students could easily revise and contextualize their work outside of the classroom. In previous iterations of the

assignments, there was a clear distinction between an initial and subsequent attempt at plotting: before and after comparison with a classmate. For the web app iteration, this became much more fluid and dynamic, since a student’s own plot and the plot of classmates could be revised simultaneously. Revision was more integrated into the assignment; the downside of this was that I was not able to directly observe the extent and quality of student revisions. In previous iterations, collaboration centered around data sharing; in the most recent iteration, since the app does the work of sharing data, there were in fact less obvious opportunities for collaboration, a point I return to in the conclusion.

Enter Formant Values

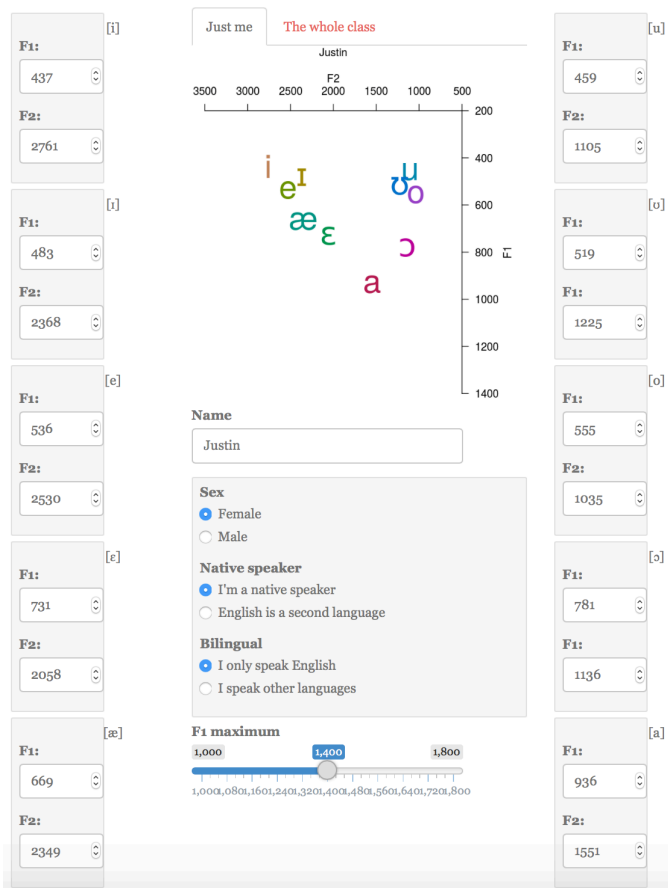


Figure 6. Screenshot of interactive vowel plotting app created using the shiny package (Chang et al., 2016) and phonR package (McCloy, 2015) for R (R Core Team, 2016).

With respect to the technology, my impression, based on the small amount of technical support I had to provide, was that students negotiated the web app handily. While we must be careful not to treat millennial students as a homogeneous group, it has been observed that many millennials are particularly at home with a

web app, which is more user-centered and visually appealing. As Hoffman et al note, millennials have “a tendency to use trial by error” and “are much more likely to push several buttons on a new phone to figure out how it works, rather than read the instruction manual” (p. 12). Given the prevalence of apps, I would expect that indeed most individuals, regardless of generation, would have a certain level of comfort with the text fields, radio-buttons and drop-down menus that appear in the app.

Meanwhile, I was able to work with the same powerful tool used in research and expose students to some of its more powerful features. With little effort, I was able to add options for scaling axes, changing units and plotting the vowels from different groups of students on the same plot. The act of exploring the options, however, was left to the individual student. Indeed, I observed informally that, given the power to “screw around” with the data using these tools, students were much more likely to make original observations and advance different hypotheses.

CONCLUSION

I have framed the development of the vowel visualization assignment as a path through different levels of technology, with the goal of minimizing technological distractions while optimizing best practices for quantitative literacy. The current, web app iteration offers a compromise between the power of the command-line and a familiarity of a Web 2.0 user experience. Further, it incorporates several NICHE best practices for quantitative reasoning instruction, including active learning, using technology and a learning process with rich feedback and opportunities for revision. I would encourage other readers to include a web app such as this among their menu of available technologies. More importantly, however, I want to advocate the iterative process of reviewing and revising assignments. By attending to the NICHE best practices, I was prompted not to be satisfied with the first (or second or third) technology I tried. In my search for the right technology, I became increasingly aware of the advantages and limitations of any one particular technology.

The web app iteration leaves three of the best practices underdeveloped: collaborative instruction and group work; scaffolding the learning process; and pedagogy that is sensitive to differences in students’ culture and learning styles. To address these, I wish to explore the following additions in subsequent iterations. First, I would like to explore the use of multiple

technologies within the same iteration. For example, in order to provide more scaffolding and acknowledge different learning styles, I would like to model the vowel plotting with an ungraded (and therefore low stakes) exercise in which we measure the same person’s vowels as a group and then plot the vowels on paper and pencil. Second, I would like to include more meaningful group work in which students choose to take responsibility for reporting on specific vowel space comparisons. Textbook descriptions of F1-F2 vowel space are typically based on an “average” male speaker of standardized English. By examining published descriptions of other vowel systems—for example, from women, children, bilingual speakers, speakers of regional and/or stigmatized dialects, students will be in a position to critically examine what is authoritatively presented as normal. In addition to encouraging student-led group work, the goals of this task would also be to introduce critical reading and to explicitly acknowledge students’ cultural differences.

To conclude, I will return to the issue of teaching quantitative literacy in a field that is not perceived, at least by students, to be quantitative. At no time, for any of the iterations of this assignment, did I frame the assignment in terms of quantitative literacy, learning to measure or learning to make plots. Similarly, although I as the instructor was guided by the NICHE best practices for teaching quantitative literacy, at no time did I revise the assignment with the goal of including more/better quantitative literacy. Rather, in both cases, the emphasis remained on authenticity: I was determined to develop a more authentic assignment and I motivated the assignment to students as an example of what real linguists do. Quantitative literacy is important in my course because quantitative methods are important in my field. For this reason, quantitative literacy ought not be regarded by the instructor in a non-STEM field as an add-on to existing course content, but ideally as an integral part of teaching students how to be a historian/anthropologist/classicist/etc.

This is equally true for literacies in STEM fields. Much scholarship in the last decade has pointed to the benefits and importance of teaching writing in the undergraduate science curriculum (e.g., Adams, 2011; American Psychological Association, 2016; Coil et al., 2010; Gillen, 2006; Krontiris-Litowitz, 2013), even though writing as a discrete subject is more associated with and taught by scholars in the humanities. As Gottschalk and Hjortshoj (2004) observe, for instructors who have not previously included writing in their classes, “teaching writing will appear to be something

other than teaching philosophy, evolutionary biology, or microeconomics [...] Who am I to teach writing?" (pp. 5-7). It is likely that most scientists have not received training in teaching writing; similarly, scholars in the digital humanities and other non-STEM fields may not have received training in quantitative literacy instruction. Gottschalk and Hjortshoj's response in the case of writing—and my response in the case of quantitative literacy: "For your course and field of study, you else is going to teach [it] if you don't?" (p. 7).

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