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DIGITAL INTERACTIVE LESSONS IN PHONETICS AND PHONOLOGY: EXAMPLES FROM THE PORTUGUESE-SPEAKING WORLD

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In this paper we describe the motivation, implementation, content, and assessment of a digital workbook used for the teaching of Portuguese phonetics and phonology, focusing on mid-vowel contrasts and their lexical and sociolinguistic impacts. The digital workbook incorporates multimedia into interactive lessons and exercises that accommodate students with diverse learning styles.

Keywords: Language Teaching, Portuguese, Phonetics and Phonology, Mid-vowel Contrasts, Information Technology.

I. Introduction: The Importance of Information Technology in Language Teaching

Information Technology has been transforming the way we teach and learn in different fields. For example, in the field of Applied Linguistics, researchers and educators have been experimenting with new technological tools since the 1980s. It goes without saying, as in any live and vibrant discipline, that in the beginning there were an intense debate and heavy criticism around this new teaching approach (Clark). Currently, for most of the profession, however, the "question regarding the use of technology to support language teaching has shifted from 'whether' to 'how'" (Hoppingarner 222). This new trend stimulates collaborations across disciplines, which in turn enjoy a beneficial impact from the continuing advancements in the digital world.

In this article we report an ongoing project consisting of a website, or a "digital workbook," that combines the teaching

of General Phonetics and Phonology with the teaching of Portuguese Phonetics and Phonology and language variation in the Portuguese-speaking world. We designed a flexible website with the goal of an infrastructure that could be easily adapted in the future to teach other academic subjects, including other foreign languages, the history of the human language, the history of different languages (integrating historical texts), and music (singing). The main features of the website are 1) a universal talking head that has the potential to teach many aspects of articulatory phonetics and can be transposed to teach the sounds of any language; 2) an online interactive language learning program, focusing on providing educators, students, and researchers of Portuguese with a more dynamic and flexible system for auditory and visual learners; and 3) an archive for the macro and micro variants of Portuguese, taking into consideration their many grammatical and social aspects.

The website offers students different learning menus so that they can draw on their strengths to increase and synthesize knowledge based on their needs, interests, learning styles, and last but not least, course requirements. For example, a student of Portuguese can learn enough articulatory phonetics, without having to examine too much theoretical apparatus, to tutor her/himself to produce the most intricate sounds of the language. Conversely, a student of Linguistics can study articulatory phonetics in depth and use Portuguese as an example to illustrate certain concepts.

II. Digital vs. Pen and Paper Approach

The first question to ask when designing a web site – or a "digital workbook" – is if it will have features that cannot be replicated on paper. After all, it is neither an easy nor an inexpensive task to put together a site. Therefore, one has to be clear on what are the advantages of an instructional web site vis-à-vis a low-tech paper version of the same materials. We also have to investigate if there are any tasks that could not be accomplished without the help of the computer. As it will become clear in the next section of this essay, our website attempts to contemplate different learning styles and

learning needs. The flexibility that internet-based tools provide for users is outstanding. Any kind of learner can take great advantage of this medium insofar as s/he can choose different paths in order to better approach the same set of materials. For example, students can learn how to produce a new phoneme in a foreign language depending on their learning style. If they are more visual, they will have access to a vast gamut of materials ranging from simple drawings to a sophisticated "talking head" that mimics the mechanics involving sound production in the vocal tract. If students are more auditory oriented, they can take advantage of a series of short video clips and long sociolinguistic interviews. These numerous approaches to learning a new linguistic contrast may all be accessed in a single user-friendly website.

A paper-based environment offers fewer learning options to students. They are more dependent on their professors and classroom time might sometimes be less available or ineffectively used. For example, in a website, students can listen to the same sound over and over again and better prepare themselves for classes. Teaching Phonetics becomes more appealing using digital technology: students can have access to the mechanics of speech production inside the oral, nasal, and laryngeal passages.

In addition, the immediacy and variety of feedback are often perceived as an advantage of digital books over paper-based ones. Different types of Computer Assisted Language Learning (CALL) feedback may range from simple "wrong, try again" to more sophisticated "elaborative feedback in the form of hints about incorrect answers" (Murphy 107). The possibilities seem almost endless. For example, a number of CALL programs offer "instantaneous feedback in the form of graphic displays such as spectograms and wave forms" (Neri et al. 452) that can visually represent differences from the target pronunciation.

Without a shadow of doubt, a digital "book" is more flexible and, therefore, has the potential of offering more input not only quantitatively but also qualitatively. Of course, such a project involves professionals from different

disciplines. In addition of experts in Linguistics and Applied Linguistics, it is crucial to involve creative and resourceful Information Technology specialists.

III. The Digital Workbook Project

As we have mentioned, our ongoing project aims at exploring digital interactive resources for teaching phonetics, phonology, and language variation. Our initial lessons focus on the Brazilian variety of the Portuguese language, but in the near future we will add lessons about other Portuguese-speaking countries. We re-affirm that the most important feature of our digital workbook is its flexibility. It can easily be adapted to the teaching of virtually any language.

On the main page (available at http://portugueselinguistics.fas.harvard.edu), one finds a general explanation about the website and a simple menu with three choices "Main," "Lessons," "Exercises." Our goal is to maintain all future lessons and exercises structured the way they are at present. Typically they are structured so that students can choose to study both the mechanics of the new phonetic/phonological phenomenon and language variation resulting from the different uses of the linguistic item(s) explored in the lesson. This structure is based on the work of S. P. Corder, who was a pioneer in integrating linguistic variation into second language teaching. Furthering the ideas of Labov, Corder argued that a language cannot be defined exclusively by a set of invariable rules – rather, it requires some variable rules as well. He explains that "an invariant rule in English would be that a definite article and a possessive adjective cannot occur before the same head noun, e.g. **the my book* […] a variable rule would be to say the word *soften* could be pronounced [sɔ̊fṭn], [sɔ̊fn̩] or [sɔ̊fn̩]" (56-57). Similarly, while in Brazilian Portuguese there is an invariant rule that a word cannot begin with the consonant sequence *mg-*, there is a variable rule that unstressed syllables cannot be lax, as Northeastern varieties pronounce *t[ɛ]levisão* instead of *t[e]levisão* 'television', thereby showing variable allowance of lax (called below low-mid) vowels in unstressed syllables (Lee and Oliveira).

In this article we will use our first lesson to illustrate some of the unique features of our digital book. We chose four Portuguese vowels that share important phonetic traits and, at the same time, important phonetic differences. Two of them are mid vowels /e/ and /o/ and the other two are low-mid vowels / ɛ / and / ɔ / (sometimes called 'lax' vowels; see Wetzels); two are rounded /o/ and / ɔ / and two are non-rounded /e/ and / ɛ /. Finally two are front vowels /e/ and / ɛ / and the others are back vowels /o/ and / ɔ /. Pedagogically, these vowels are useful in teaching both important and difficult minimal pairs (invariable rules) and regional variation (variable rules). They also present interesting features that can be captured by technological resources easily available. Video clips are ideal to teach lip-rounding and to introduce students to language variation. The talking head is instrumental to teach the points of articulation. For example, to produce a front vowel, the tongue body has to go forward in the mouth and gradually rise.

As any Spanish speaker who studied Portuguese knows, learning how to pronounce and understand the Portuguese low-mid vowels can be a daunting task (Simões; Teschner and Simões). In addition, these vowels are very productive in Brazil as the choice between mid vowels and low-mid vowels in unstressed position is a shibboleth, as it can reveal not only speakers' geographic origins, but also their age, gender, and socioeconomic level.

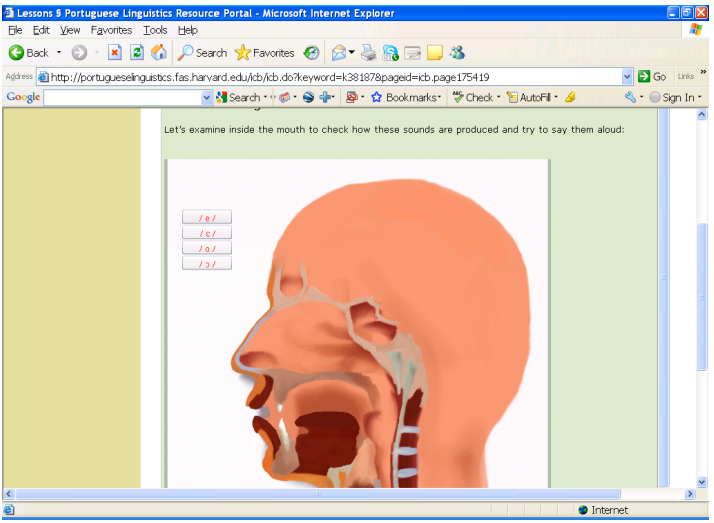
All lessons start with a brief introductory text summarizing the main features of the topic focused on the lesson. On the bottom of the page there is a short pre-assessment lesson. On the top of the page there is a menu divided into introduction, plus five parts and, finally, a post-assessment lesson. Part I has a drawing of the vocal tract showing the points of articulation of the specific phenomenon – ideally presented in minimal pairs – that will be explored in the lesson. Our first lesson is slightly different from the others on its first page. As most "first lessons," it is meant to be an introductory lesson, and therefore provides an overview of the articulators, or in other words, it reviews basic concepts

to understand enough phonetics to make better use of our digital workbook.

Part II has still images of a speaker's mouth producing phonemes. Whenever possible these photos depict the enunciation of minimal pairs, such as *avó* 'grandmother' vs. *avô* 'grandfather'. In our first lesson, these illustrations of the mouth show the differences in production of a rounded and a non-rounded vowel. Therefore, students have the chance to visually understand how the lips should be positioned to produce this contrastive phonetic feature.

Part III has one of the main features of the website: a universal talking head that has the potential to teach many aspects of articulatory phonetics, which could be transposed to teach the sounds of any language. This talking head is a pilot animated speech production system, the goal of which is to illustrate the articulation of all of the major sounds of the International Phonetic Alphabet. Currently, the most comprehensive talking head is available at the site of the *Phonetics Flash Animation Project* at the University of Iowa (www.uiowa.edu/~acadtech/phonetics/). It contains the phonetic sounds (all of the vowels and consonants) of English, German, and Spanish. However, despite the impressive number of phonetic sounds that this talking head can produce, it does not fulfill the needs of illustrating Portuguese phonetics. For example, it shows the points of articulation, but does not take into account the airflow or lack of it. This is an important issue for a language that has nasal vowels and, therefore, needs a talking head capable of simulating the airflow mechanics to depict these important phonemes.

Our talking head allows students to see, however many times they wish, a simulation of the articulators working inside the vocal tract while producing different phonemes. The image below, a screen shot of our digital workbook, shows a picture of our talking head with a menu that allows students to examine a simulation of the articulators producing these four distinct phonemes of Portuguese.



In Part IV, students have the option of studying the points of articulation by watching a video clip of a native speaker, who is either facing the camera or in profile, pronouncing contrastive phonemes of the language under study.

Lastly, we have in Part V, a map of the country or region we are studying. We pre-select words that present considerable variation across a certain region and include native speakers' recordings of this corpus. After the different voices are digitized, students have the opportunity of clicking on different parts of the map to listen to a variety of pronunciations. A relatively long post-assessment closes each lesson. In the case of our first lesson, we had a map of Brazil that shows an imaginary linguistic line between the North and the South of the country. In the South, people use mid vowels in unstressed pre-tonic position and, in the North, people tend to use low-mid vowels in the same context (Leite and Callou).

Each lesson is followed by a set of exercises presenting different levels of difficulty. Basically, there are seven types of exercises: repetition of discrete sounds; listening and watching conversations / dialogues/ interviews; phonetic transcription of parts of the conversations / dialogues / short

texts; true or false; multiple choice; drag and drop; and short essays. Some types of exercises appear in every single lesson, such as the repetition of discrete sounds and a sociolinguistic interview. Others appear in most of the lessons, but in different fashions. For example, the drag and drop exercises can be adapted and used in so many ways (e.g. categorization tasks, interaction with maps, etc.) that one can have the impression that the exercises are much more diverse than they actually are.

Another advantage of the current platform is the ability to feature some exercises more geared towards linguistics students and others that are more appealing to language students. Alternatively, we can present the same exercise, but explore different aspects of it according to the audience. Short essays are a good example of this possibility. We can offer students the choice of three or four topics for the same essay, organized in such a way that some topics would be more appropriate to language students and others for the linguistics students.

Exercises are in general accessible to audiences with different language levels and linguistic background. The sociolinguistic interview could be a good illustration of leveraging this flexibility with a digital medium: even though the interview is entirely in Portuguese, the student has the choice of having subtitles either in English or in Portuguese (which can be changed in real time).

Our next step in the project is to strengthen our feedback system. For example, we intend to record the student's voice during pronunciation exercises. This recording will be sent to a grader who will also be able to record his/her voice with corrections and recommendations and send everything back to the student. Another option would be to have spectrograms and wave forms accompanied by previously stored displays of model utterances pronounced by a native speaker (Neri et al. 452).

We intend to implement more "elaborative feedback": following Van Der Linden's lead (65), we will keep our metalinguistic explanations short, and refer students back to specific parts of the website where they can review

explanations and examples. Whenever possible we will provide students with hints using preferably a "question format" such as "are you sure you have to round your lips to produce this sound?" in order to insure that self-correction is executed in every single exercise. In sum, we intend to avail ourselves of CALL's advantages over classroom settings: "Whereas in traditional foreign language classroom situations, feedback is not very systematic or immediate […]" (Van Der Linden 62), in the CALL context, we have the possibility of simulating "individual attention" to every student.

IV. Technical Challenges

We chose the Flash and Flex platform technologies (from Adobe) to develop the rich interactive media (RIA) modules for this project. Using available prebuilt components with minimal customization in both these platforms allowed us to streamline the application development process. These applications were coupled to and driven by content (data) stored in an XML (Extensible Markup Language) format. Students programmed the modules in conjunction with instructional RIA developers under the auspices of a university wide student technology fellowship program.

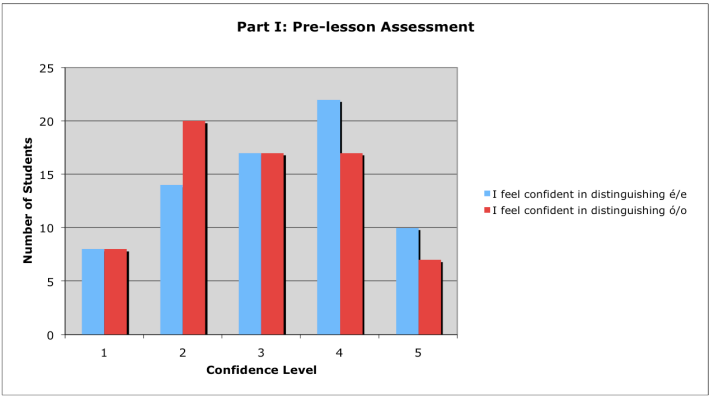
Aside from the pedagogical design, the production of digital media for each lesson and exercise involved a dedicated and coordinated effort by instructors, students, instructional technologists and native speakers that volunteered audio and visual content for lessons and exercises in the project. Detailed art pieces for the talking head interactive lesson module had to be custom created, animated (articulated) and manually synchronized to the corresponding audio files. Production of audio and video media required a careful casting of native speakers (with pronounced accents from each separate region) prior to the recordings. To maximize the quality of the media, recordings were done in a dedicated recording studio within the university in collaboration with specialized audiovisual technologists. Fellow students and technologists did

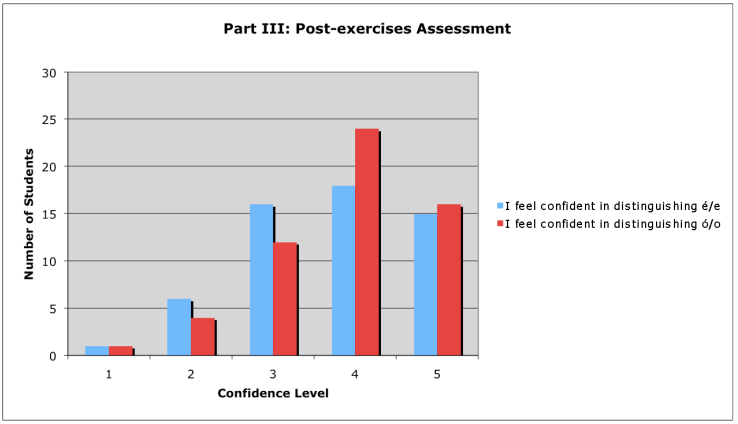
postproduction editing of media to prepare the clips for programmatic integration with the application modules.

During this initial project phase we lacked a graphic user interface (UI) for entering the content, therefore the module workflow had to be manually constructed in XML for each lesson and exercise. This final step in the process was lengthy and required meticulous attention to details to minimize parsing errors by the application.

V. Student Assessments

In this section, we report on the results of student assessment. As the lesson was piloted with students with varying levels of interest in linguistics and with varying learning styles, it was important to see the success of our initial pilot. Our participating students completed both a pre-lesson assessment, before completing any of the exercises or lessons, and a post-exercise assessment. As the graphs below show the completion of these exercises increased students' confidence for this vowel contrast. We presented a 5-point scale to 65 students.





The graph on the top demonstrates a wide range of responses in self-confidence, distributed widely from 1 to 5 and with a strong mean in the middle. As the graph on the bottom shows, students that completed the exercises showed a narrowed set of responses in the 3 to 5 range, with a mean higher than before. This comparison clearly demonstrates that students gained confidence in their ability to distinguish the mid-vowels as a result of completing the lesson.

The following 5 questions were presented as yes-no binary choices. We include the percentage of 'yes' answers in the table for 65 responses.

Assessment Question	Percent Yes Responses
I found this lesson useful	90%
I think that the various parts of the lesson are well-integrated with each other	92%
I think that the lesson provided insights into the relationship between pronunciation and regional identity	85%
I feel that this lesson has helped me better understand some concepts of linguistic phonetics	85%
I feel that this lesson has improved my confidence in understanding spoken Portuguese	81%

As the results show, students found the lessons to be useful, well-integrated, and worthwhile in improving their confidence. Moreover, the lessons improved their knowledge of phonetics and sociolinguistic issues in Brazilian Portuguese.

In general, as the above survey results show, we received extremely positive feedback from the majority of our participating students. The last question of our assessment was open-ended, asking "What did you like the most about this lesson?", and this assessment question prompted interesting comments from students. Many of them mentioned the visual component of the website as one of its main assets. Examples one, two, and three below attest to the fact that video and animation are amongst the students' favorite features in the website. These are examples of resources that would be nearly impossible to have in a traditional paper workbook.

Example 1: "It showed how to move my mouth while making the sound. It allowed me to learn visually which is easier rather than just auditorally."

Example 2: "The explanation of how the vowels are created and where they come from in the mouth/throat – very good illustration and very helpful to replicate."

Example 3: "The figure of the human mouth which said the different vowels every time we clicked on them."

As we can observe in the first example, students understood that the website offers them many choices in how to approach the learning of a new phonetic contrast. Having a variety of pedagogical possibilities helps us to fulfill the goal of building a flexible website that takes into account different ways of learning according to students' needs, linguistic background, and learning styles. The second example shares with the first one an interesting point as both reveal that learners tend to use several strategies to improve their performance. In the first case, the student relies both on his/her auditory and visual skills to improve his/her Portuguese language acquisition process. In the second example, the student relies both on the written explanation offered at the site as well the abundant visual cues.

In the examples below, students comment on the independence that our digital workbook helps them to achieve. As it is clearly stated in example 4, the website offers the possibility of practicing their language competence, in an accurate way.

Example 4:"As far as pronunciation I think this lesson did the most it could do without having a teacher in front you making sure you are pronouncing correctly."

Example five also testifies that students appreciate the website flexibility. It allows students to do the same exercise as many times as they need. Another interesting feature that was highly praised by students is immediate feedback.

Example 5: "I really liked the exercises, which were very well designed. I like the drag-and-drop stuff and the immediate feedback. I think constantly doing drills like that is the best way to learn."

In the final part of the assessment, we had an open-ended question that sought to investigate which parts of our digital workbook students perceived in need of improvement. Not surprisingly, features that were praised by some students were viewed as less appealing by others. Example 6 is an interesting case to illustrate this issue:

Example 6: "It's hard to decide. I liked having all of those elements to reinforce each other. Written explanations, I guess, were the least helpful when it comes to figuring out how a vowel should be pronounced. Just reading about a sound doesn't make much sense, unless you are comparing that sound to sounds we are familiar with in English words."

Although the student acknowledges that it is worth having different ways for presenting the same phenomenon, s/he does not think that written explanations are effective. Example 2, as previously discussed, offers a different viewpoint. In other words, even though both students subscribe to an eclectic learning approach, one of them praises the written explanations and the other doesn't particularly like this feature. Examples 7 and 8 show that many students perceive drills as beneficial to the foreign language learning process. In example 7, the student would

like to have his/her voice recorded and to receive automatic feedback.

Example 7: "Ideally it would be great to repeat the 'sounds,' have them recorded and immediately checked by the computer hence providing 'live' immediate feedback as if we were in a real life situation. Overall this is a very encouraging project."

Example 8 proposes a comparative approach that might have a positive impact in many cases. For example, teaching a Portuguese class populated primarily by Spanish speakers it is sometimes a good idea to resort to an English phoneme that does not exist in Spanish.

Example 8: "I would just like more drills. I thought this was a good lesson, and it helped me, so I'd like to have more drills available to practice with. I think it might help to compare these sounds to their counterparts in English words."

Finally, examples 9 and 10 reveal an interest in sociolinguistics. In example 9, the student is clearly asking for more input related to diachronic variation and in 10 there is interest in diatopic variants, or in other words, in geographical variants.

Example 9: "Some explanation of the cultural history behind the fundamental linguistic differences would be interesting."

Example 10: "A conversation between two people of distinct regions in Brazil that would allow us to differentiate between the way they speak."

Overall, students were enthusiastic about the digital workbook. None of them questioned the usefulness of the project. We have received constructive criticism that will be valuable for the next phase of the website, or for other researchers interested in pursuing second-language pedagogy through digital means.

VI. Limitations and Future Developments

This project is time-consuming and involves the work of a whole team of specialists including linguists, applied linguists, IT specialists, actors, and graphic designers. All of

these resources are obviously not inexpensive. Ideally, the energy invested in this website can be adapted for a large number of languages to diminish costs and duplication of effort.

The assessment portion needs further polishing in some aspects such as anonymity. In the lesson we analyzed, answers were not anonymous, as we assigned the task to our own students. Although the lesson was not a course requirement, we gave students extra credit, and thus had to identify them to reward their work. Therefore, we are unsure whether the absence of harsh criticism was due to a desire, conscious or not, to please the professors.

In the future, we will focus on creating new content for lessons and exercises and reusing existing modules. We plan on building and integrating a web-based UI front end tied to a back-end database that will streamline the process of adding and editing new content for each module. Finally, we intend to strengthen our feedback system using resources such as visual and auditory cues in the case of responses that diverge from the target answers.

VII. Conclusion

There is no doubt that an interactive digital workbook of this type cannot be replaced by paper and pencil. The site aggregates in a single place a number of diverse media that would be cumbersome, to say the least, to put together for both the classroom environment and/or for self-instruction. Visual and auditory learners have a large number of choices to improve their performance in the target language.

Students highly praised the availability of immediate feedback, the possibility of doing exercises as many times as they wish, and the advantage of not being 'on the spot' in front of peers when making mistakes. They also acknowledged that various media may complement or reinforce each other.

One of the main qualities of our online program is its flexibility at different levels. For example, we can add numerous media, links, and content. We can also easily update and fix content with little additional cost. In addition,

it can be adapted to a number of purposes including singing and vocal training, the treatment of speech pathologies, and the challenging contrasts of non-native phonemes in second-language learning.

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