TEACHING AMERICAN ENGLISH SOUNDS TO BLIND AND LOW VISION LEARNERS USING
ASSISTIVE TECHNOLOGY

By

Yeimy Maritza Medina Gonzalez

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Teaching English to Speakers of Other Languages—Master of Arts

2020

ABSTRACT

TEACHING AMERICAN ENGLISH SOUNDS TO BLIND AND LOW VISION LEARNERS USING
ASSISTIVE TECHNOLOGY

By

Yeimy Maritza Medina Gonzalez

This project was designed to improve the inclusive nature of courses on language learning and

teaching through the creation of Adaptive English Phonetic Tools (ADEPT) to provide better access to

the International Phonetic Alphabet (IPA) symbols and the sounds they represent for blind and low vision

learners and teachers of American English as a second or foreign language. This approach involved the

integration of auditory and tactual information to facilitate the development of phonological literacy

based on the effectiveness of multisensory training protocols. ADEPT consists of sets of tactile IPA

symbol cards, and a companion website based on the Universal Design for Learning framework. Each

IPA symbol card includes the symbol, its typographical description, and a reference number associated

with the website (all with corresponding Braille notations). The website includes printed and audio-

recorded information on the articulation of American English consonants and vowels with recordings of

each sound in isolation and in sample words. The pedagogical efficacy of these tools was tested with 21

adult learners of English in Colombia with a focus on vowel production. A pretest-posttest design

involving the delayed repetition technique was used. Learners' productions of short sentences with

multiple exemplars of American English vowels were audio-recorded. Native-speaker ratings revealed a

significant improvement in learners' pronunciation after 10 weeks of instruction. Qualitative data

included pre- and post-study interviews and the researcher's instructional notes. Learners described the

auditory-tactual approach as "invaluable". Field testing of the symbol cards indicated that they should be

3D printed for sustainability. In sum, ADEPT can facilitate a collaborative learning environment for

sighted and non-sighted individuals.

ACKNOWLEDGMENTS

the inclusive environment in EFL and ESL classrooms. All the things I learned from them will be invaluable in my role as a teacher for the rest of my life.

Finally, I give thanks to God for giving me an amazing family, my parents Maria and Jorge, and especially my sister Martha who was always there for me without hesitation to give me her hand and encouragement. Along the way, I also met Agustin, a special person who changed the meaning of the word *love* in my life. His support and company although often from a distance were vital in making it possible for me to continue to face different challenges, and celebrate my big or small triumphs every day during this great achievement.

Many thanks also to everyone who believes that a disabled condition is just another characteristic in some individuals. It is important to understand that all of us share the same dreams, fears, joys, and sorrows, and although we may have some boundaries in terms of functioning effectively in some fields, we are able to create and transform the world in which we are living!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

Introduction

Knowledge of phonetics (how speech sounds are produced, transmitted, and perceived) is critical to the general study of language, and more specifically, the development of phonological literacy among language learners and teachers (Hardison, 2014). Phonetics should be taught with the same importance as other linguistic elements in classes focused on English as a foreign language (EFL). As an English teacher for many years in mainstream schools and a social organization, I was aware of the limited range of pedagogical materials available to teach phonetics to EFL learners. Therefore, it became important to me to consider the design of possible strategies or tools for pedagogical purposes, emphasizing, in particular, the need to create didactic materials based on the Universal Design for Learning (UDL) guidelines from the Center for Applied Special Technologies (CAST, 2018) for all learners, even those who have visual impairments and may lack easy access to a dictionary or multimodal resource for phonetic symbols. To address this need, Adaptive English Phonetic Tools (ADEPT) were created that can be used in many different inclusive educational contexts.

This is a very important project for my personal and professional life. As a graduate student in a TESOL program, a Fulbright grantee, and a blind person, I feel I now have the experience and knowledge to bring to the visually impaired community, in particular, and all learners of English, in general, the necessary access to this linguistic component through new tools to facilitate the production and perception of American English sounds. This tool will improve the English learning process for the visually impaired population given that the majority of existing mainstream resources for learning English often depend on visual content that is not truly accessible to them.

Based on my experiences as an English teacher and student, ADEPT can fill many gaps in the EFL classroom in my country, Colombia, as well as in a range of visually impaired communities, allowing these learners to grow more easily in their oral skills, become more cognizant of their own

abilities, and understand better the importance of the production and perception of the different sounds that shape the English language.

Moreover, the impact of the use of ADEPT can be understood within the framework of multisensory (auditory and tactual) learning and the Universal Design for Learning. Multisensory training protocols are more effective for human learning than those that depend on only one sensory modality (e.g., Shams & Seitz, 2008). Learners with visual impairments need hands-on experiences with learning objects paired with auditory information to maximize comprehensible input for learning. Materials that address both senses can be used by sighted and non-sighted learners collaboratively to help them articulate their new knowledge and develop good strategies applicable to various educational contexts.

Universal Design for Learning

This relatively new concept is the most important pedagogical strategy that supports all of my research. All students have different needs, abilities, and preferences. Neither their strengths nor their barriers to learning are always obvious. They tend to be the students who have been marginalized—those who need different kinds of support and scaffolding to learn (Rose, Meyer, & Hitchcock, 2005). They need different adjustments to have a successful learning experience. Everyone has different conditions and characteristics, and the role of education is to accommodate them in order to create an effective learning process that helps them reach their goals.

Many years ago, teachers believed this kind of learner population should be segregated in special schools to receive ideal instruction for their condition. Nowadays, students with disabilities go to mainstream schools to receive the same quality of education as other students. It is in this scenario that UDL appears as a new way to rethink education as a space for all, as an inclusive setting where everybody can learn. Individuals who usually struggle to learn for a wide variety of reasons include those with sensory or physical disabilities, emotional or behavioral challenges, learning disabilities or reading difficulties, autism spectrum disorders, attention deficit hyperactivity disorder in addition to those who lack appropriate background knowledge, and have English-language barriers.

As the above list indicates, there is a broad range of situations that generate many needs for students. Unfortunately, the typical curriculum—usually centered on printed materials—is designed for a homogeneous group of students and is not able to meet different learner needs. In the field of language teaching, the use of visual resources is very common in the classroom. The majority of language teachers use the visual channel as the main tool to provide input during classes, triggering a difficult class environment for students with visual impairments. It has always been ironic for me as an English teacher to find that many English textbooks, dictionaries, and now, digital resources created for teaching languages are completely inaccessible. Language has a visual component (e.g., non-verbal communication) but the most prominent modes of production are oral and written. These are processes that are very natural and easy for a visually impaired student to develop. Some of my students usually ask why there are obstacles to language learning if language is natural for us as human beings.

The UDL, defined in the Higher Education Opportunity Act of 2008 (U.S. Department of Education) as a "scientifically valid framework for guiding educational practice," turns this situation around. UDL puts the burden of change where it belongs: on the curriculum itself. By facilitating the design and implementation of a flexible, responsive curriculum, UDL offers options for how information is presented, how students respond or demonstrate their knowledge and skills, and how students are engaged in learning. UDL implementation provides the opportunity for all students to access, participate in, and progress in the general education curriculum by reducing barriers to instruction.

The origin of UDL in the late 1980s can be found in the Center for Applied Special Technologies as the result of the alignment of three conceptual shifts: advancements in architectural design, developments in education technology, and discoveries from brain research. Later, technological advances allowed alternatives to the "one-size-fits-all" academic materials that used only the print medium. Access to computers was becoming more common in schools, and assistive technologies that allowed educators and students to manipulate text resulted in the availability of flexible instructional

options. At that point, text could be easily enlarged, simplified, summarized, highlighted, translated, converted to speech, graphically represented, and supported through accessible, digital materials.

The use of assistive technology is one of the pillars of the current project. The creation of screen readers has made the literary process easier for the visually impaired community. The design of a website that is completely accessible to everybody is one of its major objectives, and is the best demonstration of the efficacy of assistive technology and its influence on this population.

It is important to understand that UDL is not a means to involve disabled students in the classroom; it is a framework that improves the outcomes of all students by eliminating or minimizing learning barriers in the academic environment. UDL addresses three learning networks within a broadly defined concept of curriculum that includes goals, materials, methods, and assessment (Rose et al., 2005). According to the following three UDL principles, each area of the curriculum should provide multiple, varied, and flexible options for representation, expression, and engagement:

- Principle 1: Provide multiple means of representation (Recognition network).
- Principle 2: Provide multiple means of action and expression (Strategic network).
- Principle 3: Provide multiple means of engagement (Affective network).

The four interrelated components of the UDL curriculum require further explanation:

- **Goals** are typically described as learning expectations. They represent the knowledge, concepts, and skills students need to master. In the K-12 curriculum, the goals are usually aligned to state standards.
- **Methods** are generally defined as the instructional strategies used by educators to support student learning. Methods should be evidence-based and supported by an analysis of learner variability. UDL methods are flexible and adjusted through monitoring of student progress.

- **Materials** are the media used to present content and demonstrate learning. UDL materials offer multiple media options and include embedded supports.
- **Assessment** within the UDL framework refers to the process of gathering information about a learner's progress using a variety of methods and materials. UDL assessments are particularly concerned with accurately measuring learner knowledge, skills, and engagement by maintaining construct relevance, and reducing or eliminating irrelevant or distracting elements that interfere with the assessment's validity.

In addition to a role for UDL in the current study's development of tactile IPA (International Phonetic Alphabet) symbol cards and a companion website to assist blind and low vision learners of English, several other areas of the literature provide important components of the framework: previous studies on tools for this population; the value of multisensory learning; and linguistic, cognitive and sociocultural perspectives on the development of second-language (L2) oral production skills.

Literature Review

Fields such as phonetics, phonology, and language learning and teaching use symbols from the International Phonetic Alphabet (IPA). As the name suggests, their use crosses linguistic and political boundaries. In contrast to standard orthography, each IPA symbol uniquely represents a speech sound.

In order to make IPA symbols accessible, I began with a homemade creation, specifically pieces of cardstock, each with a raised phonetic symbol made with silicone. Although this approach was informative to some degree, it presented content in a decontextualized manner and had an isolating effect within a classroom setting. An alternative was sought. Wells-Jensen (2005) summarized several possible strategies to assist the visually impaired with the reading and transcribing of IPA symbols, including the use of IPA Braille (Englebretson, 2009).

Therefore, the current project united the use of IPA symbols, standard orthography, and Braille in pedagogical materials to accommodate a range of learner backgrounds and educational contexts in

different countries. An online search for ideas produced one existing set of tactile objects related to phonetics. Lillehaugen, Echavarría Moats, Gillen, Peters, and Schwartz (2014) developed a *Tactile IPA Magnet-board System* for the teaching of phonetics and phonology to visually impaired students. They noted that tactile magnetic classroom tools had been developed some years earlier for the learning of chemistry (Supalo, Mallouk, Rankel, Amorosi, & Graybill, 2008), and took the initiative to develop similar materials for phonetics. Their system consisted of phonetic and phonological rule-writing symbols printed using a PIAF (Picture in a Flash) machine, cut to size, and adhered to a magnetic sheet, which was then cut into small pieces to accommodate each symbol printed in a 24-point font. This was designed to allow users to move the pieces around on a magnetic board. The authors suggested the development of similar tools for use in other fields including language instruction.

Scaffolding for learning can come in different forms. Collaboration by instructional and library staff, and other students, especially in group work is important in order to provide a supportive environment to enhance disabled students' motivation to learn foreign languages (Orsini-Jones, Courtney, & Dickinson, 2005). In that study, sources of support for visually impaired students included a virtual learning environment accessed through the use of JAWS (Job Access with Speech) for Windows (by Freedom Scientific) and creation of accessible web pages. Orsini-Jones et al. reported a generally successful experience for both the blind student involved in the study and other students in the class although some difficulties were encountered involving accessibility issues with other sites and databases. The authors emphasized the need for academic programs to have input from a visually impaired user in order to understand some of the shortcomings and challenges of website access and general assessment procedures. Audio recordings of class information were helpful. An interesting concluding comment was that "blind students suffer from information overload more than their peers as they can only process language via hearing, listening and speaking, so they need to make an extra effort to compensate for the lack of sight" (p. 152). However, the tactual modality offers an alternative source of input in some cases. In terms of Braille, the National Federation of the Blind (2009) reported a "Braille literacy crisis"; specifically, fewer than 10 percent of the 1.3 million people who were legally blind in the US as of 2009

6

were Braille readers. Similar downward trends were found for the United Kingdom where fewer than 1% of the two million visually impaired people in the UK as of 2012 were users of Braille, and of that group, Braille users tended to be those who had not been able to see from an early age (Rose, 2012). These statistics were attributed to several factors including a shortage of teachers and the advent of technology such as screen-reading software and smartphone apps. However, based on the close monitoring of several college students (two visually impaired, one blind) in their foreign language studies at a university in the UK, Orsini-Jones (2009) recommended that blind students be encouraged to increase their Braille literacy in the first language and in the foreign language being studied.

Tactile information can come from sources other than Braille. Manual tactile information from placing a hand on the face of a speaker enables the accurate identification of syllables when integrated with auditory input either in noise or in the clear (Sato, Cavé, Ménard, & Brasseur, 2010). Generally, this type of tactile information enhances speech perception by about 10% over auditory input alone (Gick, Jóhannsdóttir, Gibraiel, & Mühlbauer, 2008).

The auditory modality had been the focus of most linguistic and/or cognitive perspectives on L2 pronunciation learning for years, including the Speech Learning Model (Flege, 1995, 2003). The SLM assumes that learning L2 sounds involves creating and using long-term memory representations through auditory input. Developing L2 perceptual representations or categories depends on learners' ability to detect phonetic differences between first-language (L1) and L2 sounds. Hardison (2003) extended the development of L2 perceptual categories to a consideration of auditory and visual input versus auditory only. Visual input consisted of information from a speaker's face (e.g., lip movements). A series of perceptual training studies involving several English consonant sounds (e.g., /r/ and /l/) found that focused training with auditory-visual input resulted in significantly greater identification accuracy with generalization to novel stimuli, new voices, and transfer to production improvement as well as to earlier word identification in scripted and unscripted speech (for an overview, see Hardison, 2012). Findings

supported an adaptation of multiple-trace memory theory, also referred to as an episodic or exemplar theory, for auditory-visual L2 speech learning.

In addition to incorporating multisensory input in speech learning, it is important to remember that the development of L2 speaking skills occurs within a communicative context, especially when communication is interactively co-constructed during conversational interaction involving L2 learners. Interaction-based learning occurs through the negotiation for meaning that takes place during communication breakdowns triggering modifications to make speech more comprehensible to the interlocutor (Gass & Mackey, 2015). This interaction approach is appealing as a theoretical view of L2 pronunciation learning because of its compatibility with the intelligibility principle of L2 pronunciation, which promotes a priority for intelligible pronunciation by L2 speakers in instruction versus a reduction in accentedness (Levis, 2005).

As speakers who establish a connection to the world and to each other (Lantolf, Thorne, & Poehner, 2015), we connect with our reality through language. The symbols that are conventional in a society let us understand the environment around us. In the case of blind people, many of the references in the cognitive system are created by language use. Words paint the world when a person cannot see physically. The majority of our habits and traditions are part of our heritage from the communities to which we belong. Communities, whether immediate and tangible or created through imagination (Kanno & Norton, 2003) have a strong impact on language learning by influencing learner agency, motivation, and investment in language learning (Pavlenko & Norton, 2007). This perspective fits well with the stereotype of the disabled community, which, for many years, had been seen in some societies as unable to learn another language. In those societies, second language learning is regarded as a symbol of wealth which limits access to this knowledge for many people who see themselves as distanced from the target language.

The framework of imagined communities can account for some of the observable phenomena of L2 pronunciation learning, specifically the variable paths and outcomes because every learner's imagined

community is different, leading learners to approach pronunciation learning in different ways. They come to language classrooms with their geopolitical, social, and personal histories often shaped by power structures that, in the case of English, are frequently inequitable.

CHAPTER TWO

Overview of Study

The current study had three main objectives. The first was to develop sets of tactile materials appropriate for visually impaired learners of English to help them learn IPA symbols and the sounds they represent in American English. These materials needed to be designed so they could be easily reproduced for use in a range of educational contexts, and as inexpensively as possible. The second objective was to design an accessible companion website following UDL guidelines to be used by learners in conjunction with the tactile materials. By putting these tools together, ADEPT (Adaptive English Phonetic Tools) was created. The third objective was to test the pedagogical efficacy of this multisensory (auditory and tactual) input with a visually impaired learner population. Specifically, it was important to determine if the tools resulted in significant improvement in learners' English pronunciation, and how they responded to their use.

To address the study's objectives, both quantitative and qualitative research methods were employed. A pretest-posttest design was used to assess the impact of training on learners' English pronunciation with a focus on American English vowels, which are more challenging than consonants for L1 Spanish speakers. This data collection served to field test ADEPT with EFL learners. Because the study was not designed to compare instructional methods, no attempt was made to establish a control group. Qualitative data included pre- and post-training interviews with the learners, the instructor's daily records kept during the training period, and the learners' oral and written feedback on the perceived value of the training materials and procedure.

Method

Participants

Prior to the beginning of the study, 21 participants completed an online survey in Spanish. All were citizens of Colombia; 17 of them were legally blind and four were classified as low vision. Some of

the blind participants had been able to see at an earlier age; others were congenitally blind. Most participants ranged in age from 18-35; two were in the range of 35-50, and two were older than 50. With regard to their educational level, six of them had completed secondary school, eight had completed technical education in different fields, five were professionals, and two were undergraduate students. All of them had received English instruction during elementary and secondary school since this was mandatory in all schools in the country. Four participants had taken English classes during their technical studies, eight had taken free or informal courses at different educational institutions, including language institutes, and seven had studied English as a required course at the university level.

In self-assessing their oral English proficiency level, 11 of them described themselves as beginners, five as low intermediate, four as intermediate, and one as upper intermediate. As an experienced teacher of English, I would agree with their assessments. Eleven participants had no knowledge of phonetics. One participant had received phonetics instruction during her technical studies, three knew about the topic from their undergraduate studies, and six had received some information about this field in other courses.

It was clear that some of the participants had been involved in English classes when they had been able to see at earlier points in their lives. This can confound the assessment of the success or failure of previous English learning because it is difficult to determine how much the acquisition of the disability had influenced the person's educational development. Their English proficiency could have been influenced by many factors.

All participants usually used assistive technology as an instrument of literacy during their learning process, and just two participants with low vision used a different software, ZoomText, an e-magnifier/reader (by Freedom Scientific) while the other 19 were familiar with the screen reader JAWS, which was the screen reader used in this study; it reads information on the user's screen using synthesized speech.

The last question on the survey was related to their motivation to take part in this study, and some common answers showed that they recognized English as an important tool to improve their academic and professional profiles. They also felt that learning English was a challenge for their personal lives, mostly because of the disability. Some of them wanted to participate because they considered phonetics very relevant for the understanding of English sounds, and many really wanted to improve their English pronunciation and fluency. They were comfortable with their knowledge of grammar but not with their ability to speak English. Two participants expressed curiosity about this study because its announcement on social media sounded innovative. All of them wanted to demonstrate their ability to learn with accessible materials and felt the inclusive nature of the class could offer an advantage.

Although all participants had received some English language instruction before, none of them reported a successful learning experience. The current study offered them an opportunity to restart or refresh their oral English proficiency. Following are some of their comments (translated into English) about past learning experiences.

GV: "Like the majority of the students in Colombia, I learned English in the secondary school. It was the largest amount of English instruction I had received in my life. Then, in university, in my undergraduate program, I started studying English with some modules that were never suitable for me because the majority of the activities in the textbooks required associating images with text, and I could not do it. I remember I was good in pronunciation and I had a good memory to learn English in elementary school and even until the 8th grade in secondary school. But one day, the teacher started teaching songs and I could not read the lyrics on the paper so I lost my interest for learning."

GB: "I have received basic English instruction, which means I have a few vocabulary words and basic grammar constructions. I can identify the tenses to build sentences and the written texts are friendly for me, but understanding the native speakers, or constructing quickly an oral production is too difficult for me."

It is relevant at this point to mention that this Colombian blind community is a good point of reference for the entire Latin region since the native language and educational systems are comparable, and, in general, offer a low standard of English learning, with low literacy rates for persons with disabilities. The tactile and auditory learning tools developed for the current study have the potential to create a truly inclusive society, not only in Colombia, but in the entire Latin region, where the blind population faces the same obstacles in trying to access an effective English class.

Materials

Pronunciation Pretest and Posttest. The stimuli created for the pronunciation pretest and posttest were adapted from *English Pronunciation Made Simple* (Dale & Poms, 2005) and consisted of several exemplars of each American English vowel sound in frequently occurring words in a short sentence. As shown in Table 1, there was a total of 50 vowel tokens across 16 sentences.

Table 1.

List of Sentences Used in the Pronunciation Pretest and Posttest

Sentence	Target Vowel	Target Words from Sentence
1. Peas and beans are good to eat.	[i]	peas, beans, eat
2. Tim's sister swims a little.	[ɪ]	Tim, sister, swim, little
3. Ten times seven is seventy.	[ɛ]	ten, seven, seventy
4. Many animals inhabit Africa.	[æ]	animals, inhabit, Africa
5. Doctors say jogging is good for the body.	[ɑ]	doctors, jogging, body
6. Sue flew to the moon.	[u]	Sue, flew, moon
7. This is a good cookbook.	[ʊ]	good, cook, book
8. The southern governor is Republican.	[ʌ]	southern, governor, Republican
9. The author gave a long talk.	[ɔ]	author, long, talk
10. Nurses do worthy work.	[ɝ]	nurses, worthy, work
11. Labor Day is in first week of September.	[ɚ]	labor, first, September
12. Maine is a great state.	[eɪ]	Maine, great, state
13. The North Pole is close to the Arctic Ocean.	[oʊ]	pole, close, ocean
14. Owls are now found throughout the world.	[aʊ]	owl, now, found, throughout
15. My sister has a wild life.	[aɪ]	my, wild, life
16. The auto industry is a loyal employer in Detroit.	[ɔɪ]	loyal, employer, Detroit

Tactile IPA Symbol Cards. Through interlibrary loan, the *Tactile IPA Magnet-board System* (Lillehaugen et al., 2014) was borrowed and reviewed. In designing the tactile materials for the current study, the following modifications were considered: a) an increase in the size of each object so that it would be easier to manipulate, b) inclusion of important information with the symbol on each object to facilitate learning and memory recall, and c) addition of some type of reference on each object to guide users to a companion website for additional information on the sounds, and audio recordings. Based on these modifications, several options for the size of the objects and the type of information were tested until a decision on the characteristics was reached. Despite declining rates of Braille literacy in the US (The National Federation of the Blind, 2009), the current project supports the recommendations made by Orsini-Jones (2009) and maintains Braille notation as part of its input to learners in the design of the symbol cards in order to accommodate a range of learner backgrounds, ages, learning styles, and educational contexts.

Four sets of 45 tactile IPA symbol cards were prepared. Each set included symbols for the consonants and vowels found in American English as this was the English variety of interest to the participants in the study (for a list, see http://thesis.medinago.msu.domains/). The symbols primarily represented the phonemic inventory although additional cards were created based on the difficulties that some frequently occurring sounds present for many L2 English learners, including native Spanish speakers; for example, a card was prepared for each voiceless aspirated stop (e.g., the first sound in *pet*, *top*, *catch*), the flap (e.g., the medial consonant sound in *city*), r-colored (rhotacized) vowels (e.g., *bird*, *teacher*), and each diphthong (a single vowel with continuously changing quality) (e.g., *buy, loud, toy*). The front and back mid vowels were also treated as diphthongs (i.e., [eɪ] and [oʊ]) following Ladefoged and Disner (2012).

To create each card, a file was made in MS Word using Doulos SIL phonetic fonts and the Duxbury Braille Translator (Duxbury Systems, Inc.). The Canon imageRUNNER ADVANCE 4245 copier printed the image on swell (thermal) paper. This was fed through a tactile image enhancer (by

Repro-Tronics) to produce a raised image, which was applied to a magnetic adhesive sheet (by Magicfly) to allow users to move symbols on a surface in order to transcribe words and keep each card in place.

Figure 1.

Image of a Tactile IPA Symbol Card
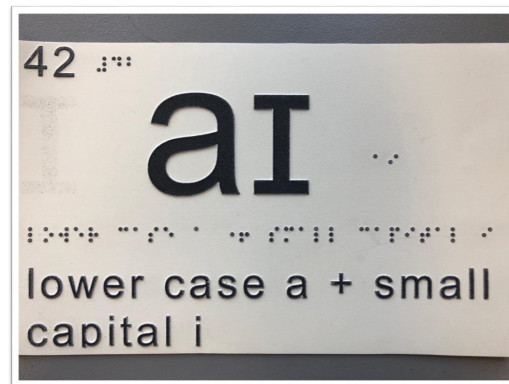
Note. IPA symbol cards were produced by the Resource Center for Persons with Disabilities, Michigan State University.

As shown in Figure 1, in the upper left corner of each card, a sequence number was printed as a tactile numerical character (48 pt. font) along with its Braille representation. This sequence number referred the user to additional information on the companion website (described below). The tactile IPA symbol (220 pt. font) was centrally located with its corresponding representation in Braille to the right. Below the symbol was the Braille representation of the simple typographical description of the symbol (Pullum & Ladusaw, 1996), which then appeared in standard orthography (48 pt. font) below that. In doing so, the information on each of these cards was accessible to both sighted and non-sighted users for collaborative learning.

Companion Website. A website was developed by Info Innova in Colombia to be used in conjunction with the IPA phonetic symbol cards although the site can be used independently (see http://thesis.medinago.msu.domains/). It was organized according to three criteria: a) the need for a user-friendly design, b) comments and suggestions from various test users who were involved with language teaching and assistive technology, and c) the principles of Web Content Accessibility Guidelines

(WCAG) 2.0. The site includes a) the names of the phonetic symbols that represent the sounds of American English, b) the typographical description of the symbols, c) information on how the consonant and vowel sounds are produced with reference to the usual descriptive characteristics for consonants (e.g., place and manner of articulation, voicing status) and vowels (e.g., height, backness, rounding), and d) recordings of each sound in isolation and in frequently occurring words. The site also includes specific technical details for the production of the symbol cards. For users, there are setup instructions for a Windows 10 computer (see Appendix A).

Procedure

This research involved both quantitative and qualitative approaches. As stated earlier, the goals were to create the pedagogical tools, test their use by language learners, and elicit the learners' perceptions of their efficacy and any recommendations for their future use. The sequence of tasks was as follows: 1) online survey, 2) pre-instruction interview by email, 3) pronunciation pretest, 4) instructional period, 5) pronunciation posttest, and 6) post-instruction interview (See Appendix B for the interview questions).

As noted earlier, before the study began, the learners received an email with a short survey in Spanish that asked them about some aspects of their language learning background, their technological skills, and any knowledge they had about phonetics. With these data, a profile of each participant was created. The profiles provided information on their needs, socio-cultural background, and previous attempts to learn English in different educational institutions.

Following the initial survey and interview, participants gathered each week for 10 weeks at a university in Bogotá, Colombia where they were acquainted with the goals of the study, the technical equipment, and the informed consent procedure which was read to them by JAWS, the screen reader. This was followed by the pronunciation pretest, which was administered using the delayed repetition technique (Flege, Munro & MacKay, 1995) as demonstrated in the following example for the target vowel [i]:

Recorded Native Speaker Voice #1: Peas and beans are good to eat.

Recorded Native Speaker Voice #2: What is good to eat?

Participant repeats what Voice #1 said: Peas and beans are good to eat.

The advantage of the technique is that the researcher can determine and control the content of the participant's production. The temporal delay between Voice #1 and the participant's recording, and the lexical content of the question (Voice #2) disrupt rehearsal by the participant and reduce imitation. The disadvantage is that although sentences are kept short, some participants can have difficulty with memory recall. Precise recall of all words is not necessary as long as a sufficient number of exemplars of the target sound are produced. Other elicitation options such as a picture prompt or the use of Braille were not appropriate for the population. Most of the participants were totally blind, and only half of them were literate in Braille. Participants' pre- and post-instruction responses were audio-recorded for later analysis.

Following the pretest, instruction using the tactile IPA symbol cards and website lasted 10 weeks. Each participant was given access to a computer with JAWS for Windows (2019 version), the most commonly used screen reader in Colombia, and a Wi-Fi connection. Training sessions took three hours per week, and in some cases, the learners had extra assignments. Instruction included an overview of phonetics with an emphasis on the consonant and vowel sounds of American English. Participants practiced perceiving and producing the sounds while they worked with the cards and companion website.

Two specific activities are described here. Participants were able to create phonetic symbols by manipulating pipe cleaners into the shape of each symbol. This was also helpful tactual feedback. They also used the Color Vowel Chart (Taylor & Thompson, 2012) to practice vowel sounds within the context of prenominal color adjectives followed by nouns that represent each vowel (e.g., *green tea, blue moon*).

At the end of the 10-week period, a pronunciation posttest was conducted using the same stimuli as the pretest. Participants were asked to provide feedback on the instructional activities, IPA symbol cards, and the website. This was done through interviews and a follow-up email. Each participant was compensated 90,000 in Colombian pesos (approximately US$28).

The instructional activities for the 10-week period are outlined in Table 2 below.

Table 2.

Summary of Weekly Instructional Activities

WEEK	ACTIVITIES
1	-Distribution of the first interview and survey by email -Introduction to the goals and general outline of the study -Installation of technical adjustments to the university computers -Review of informed consent procedure
2	-Administration of the pronunciation pretest using the delayed repetition technique -Explanation of the most relevant concepts in phonetics
3	-Exploration of the companion website -Practice in perception and production of consonant sounds
4	-Exploration of the tactile cards in groups. The class was organized into 4 small groups. Each group had a leader who knew how to read Braille.
5	-Practice in perception and production of vowel sounds -Practice in manual creation of IPA symbols by participants using pipe cleaners. -Typing IPA symbols using unicode characters
6	-Focus on vowel production and practice typing IPA symbols on the computer.
7	-More about vowel production -Using the Color Vowel Chart (Taylor & Thompson, 2012) to practice vowel sounds -Continuing the use of the companion website with the IPA symbol cards
8	-Continuing to work with vowels, Color Vowel Chart, and typing IPA symbols
9	-More practice with the website and the IPA symbol cards, especially the vowels
10	-Administration of the pronunciation posttest -Feedback from the participants -Compensation offered to the participants -Post-instruction interview by email

Results and Discussion

Quantitative Perspectives

   Rating Procedure. Three native English-speaking raters evaluated the participants' pre- and posttest audio recordings. Each was from the upper Midwestern region in the US and had several years of experience teaching English as a second and foreign language. They were given access to a password-protected website where the audio files had been uploaded. The pre- and posttest recorded samples were randomized. Raters were given a copy of the target sentences. Raters were instructed to consider the pronunciation of only the target vowel sounds (underlined in each sentence). The task was to evaluate the accuracy of the English vowel production. One point was given for a vowel that could be identified as the target sound. For example, if one of the sentences had been *The dog b<u>i</u>t the boy*, and the speaker had produced the underlined vowel as [i] resulting in *The dog b<u>ea</u>t the boy*, no point would have been given. Raters were told that mispronunciations would not always constitute minimal pairs (e.g., bit, beat). Raters completed a score sheet for each audio file and submitted their score sheets to a folder on the site. Raters were compensated US$12.50 per hour.

   Data Analysis. Of the 21 participants in the study, data from four had to be omitted from analysis because of either failure to follow task instructions or too few attempts at production during the pretest recordings. The number of target vowel sounds attempted by each of the remaining 17 participants was tabulated and used as the number of possible points for a given sentence. Participants were not penalized for failing to produce a specific target because it could have been due to reasons other than production ability such as limitations in memory recall.

   Rater judgments were evaluated for inter-rater reliability using intraclass correlation coefficient. Cronbach's alpha was very good at .98. A mean score was then calculated for each sentence produced by each participant in the pretest and posttest. Percent correct was then calculated for each participant to represent production accuracy as a proportion of the total attempts made in the pretest and posttest. In

some cases, a participant could not recall a specific word but substituted one of similar meaning. The substitution was included in the analysis if the word contained the target vowel. For example, substitution of the word "job" for *work* was not included, but substitution of "ar<u>ou</u>nd" for *thr<u>ou</u>ghout* in the phrase *thr<u>ou</u>ghout the world* was included as was the substitution of the word "g<u>o</u>vernment" for *g<u>o</u>vernor* because the target vowel was present. These meaning-based substitutions were also an indication that at least some of the participants were focused on meaning versus form during the task. This focus was also evident when a participant resorted to Spanish in order to express the meaning of a sentence; this occurred only twice.

Results. Shapiro-Wilk indicated no violations of normality in the data, $W(17) = .962$, $p = .669$ for the pretest, and $W(17) = .950$, $p = .451$ for the posttest. As shown in Figure 2, the mean percent accuracy in the pretest was 86.22 ($SD = 7.06$, 95% CI = 82.60, 89.85) which rose to 93.46 ($SD = 3.87$, 95% CI = 91.47, 95.45). A paired samples *t*-test revealed a significant increase in vowel production accuracy from the pretest to the posttest, $t(16) = 5.590$, $p = .000$. Effect size Cohen's *d* (with correction) was 1.62[1]

The most problematic vowel across participants was [ɪ]; for example, the vowel in *s<u>i</u>ster* tended to be pronounced as [i] versus [ɪ] although production of the vowel was more accurate in the other words in the sentence: *Tim, swim,* and *little*.

---

[1] See https://www.yorku.ca/ncepeda/effectsize.html for a calculator. This modified formula is a correction for the dependence between means that occurs in a within-group design and uses Morris and DeShon's (2002) equation 8, which reduces the value of *d*. Cohen (1988) suggested the following for interpreting effect size *d*: small, $d = 0.2$; medium, $d = 0.5$; and large, $d = 0.8$. These do not take the correction into account. Using *r* also provides an overestimated effect size ($r = .66$ for these data) because of the correlation between the two sets of data (e.g., Field, 2018).

Figure 2.

Mean Percent Accuracy for L2 English Vowel Production
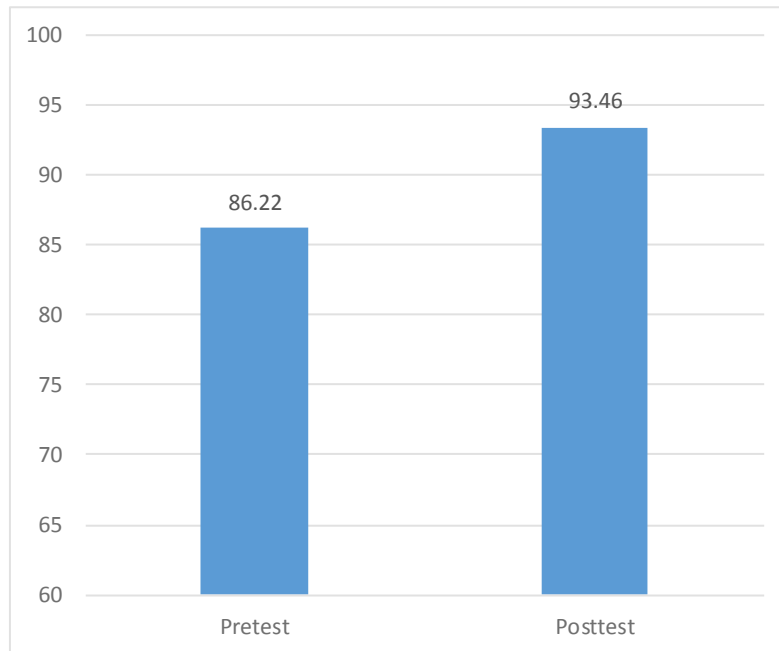

A closer look at the pretest and posttest performance of each participant is shown in Figure 3. Note that there is more variability across participants in the pretest vowel production accuracy compared to the posttest. This pattern was also captured in the smaller standard deviation found in the posttest.

Figure 3.

L2 English Vowel Production per Participant: Pretest and Posttest Accuracy as a Percentage of Attempts
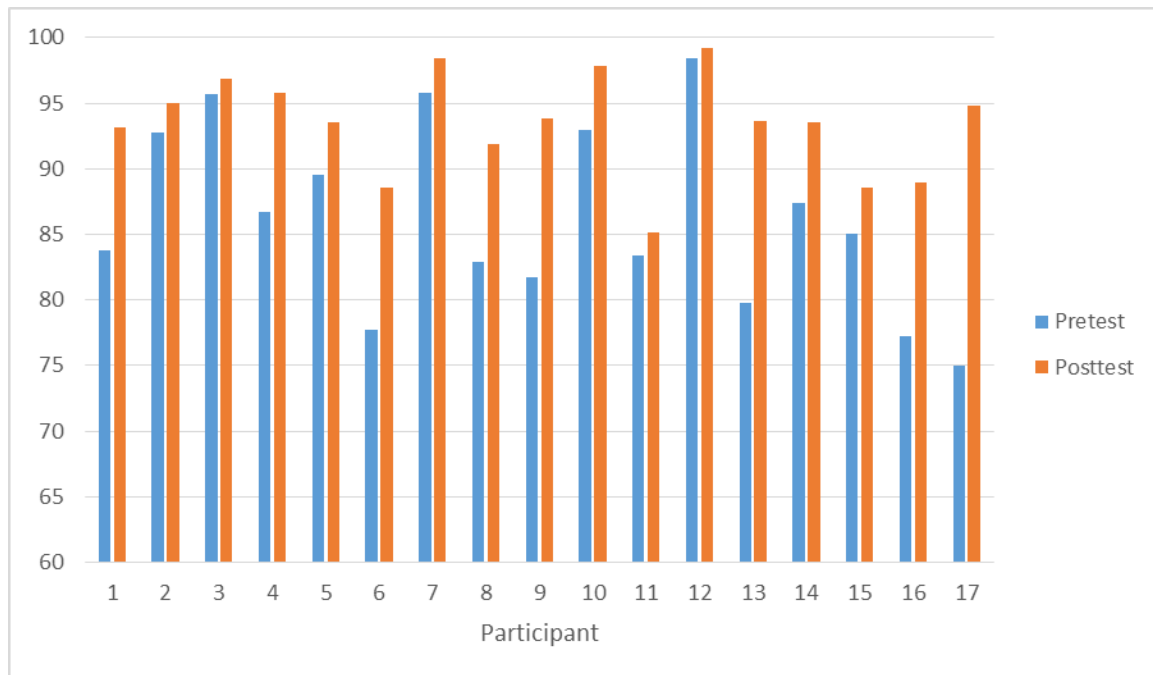
Qualitative Perspectives

In addition to the quantitative data, three instruments provided information on the participants' perspectives on the training program and recommendations for future use: a) two interviews with the participants (one at the beginning and the other at the end of the study; see Appendix B), b) my notes written after each training session, and c) a collection of comments that the students sent me by email. Some of the outcomes are presented here following the UDL model as a framework to analyze the contributions of the materials.

The first interview was focused on the learners' previous English language learning experiences and included their strategies to practice the language, the frequency of its use, their biggest difficulty in its acquisition, and the expectations they had for learning this foreign language. Here, learner identity plays an important role in the explanation of the linguistic practices of these learners. In Colombia, an interest in learning English is not common. It is even less common for people with disabilities because the

majority of this population belongs to a socioeconomic background that has not considered a knowledge of English to be a relevant skill for active participation in society. It is now becoming necessary for the visually impaired to learn a second language as more of them are able to enter higher education; however, as noted earlier, the materials and methodology for learning English are still insufficient for and inaccessible to this segment of the population.

From this interview, I found that their biggest difficulties with the English language involved oral skills. All participants mentioned that pronunciation and auditory discrimination of sounds were too hard for them. They reported not having any idea about phonemes in American English. Their correct use of vocabulary limited their fluency. It was evident that the lack of knowledge and phonetic awareness among the participants contributed to the challenges they experienced learning English.

Another topic in the interview addressed the strategies the participants used to practice English. The answers revealed many choices: a) listening to music in English and trying to understand the lyrics, b) watching/listening to some videos, especially the participants with low vision, c) reading academic papers as assignments for the university, d) using applications like Duolingo to study English grammar, and e) listening to audiobooks to try to understand some words. The majority of the activities they reported were related to the use of auditory input.

It is relevant to mention that the participants had a large range of options available for language input in different formats; however, they also affirmed that there were far fewer opportunities available to practice speaking. In the current study, the availability of more interaction with other learners appealed to them as a way to facilitate the acquisition process.

The last topic that appeared in the interview dealt with the goals or motivations the participants described for learning English. The majority of the answers mentioned the idea of improving their professional profile with the expectation of finding a better job. Some of them also wanted to communicate with speakers from other cultures and some even expressed an interest in living in another

country. One individual wanted to be able to watch videos without having to ask others to read the subtitles; one wanted to be an English teacher, and another just liked to learn languages. Knowledge of English can offer many opportunities to this community. It is clear that everybody had different motivations for learning a second language, and that they did not consider the disability a limitation in reaching this goal. They also had very positive attitudes toward American culture.

Instructor Notes. After each instructional session, I always wrote down my ideas and feelings about the process and the role that ADEPT could play in an EFL classroom. I feel very grateful for the opportunity to take such positive action for my community. When I read my students' comments, I felt that I was doing something good for someone. I think that a big part of these outcomes is because I have the same visual condition as the participants, which helps me to understand their needs and help them to become more engaged. To reach a goal of greater engagement in learning, the accessible materials and pedagogical activities were key.

To summarize my experiences as a teacher and researcher in this study, I think the most suitable word is *innovation*. All learners were curious about this experience, the idea of making something different or learning something beyond the traditional outcomes was attractive for some of them. I wrote in my diary, "Maybe the hardest point that day, was to explain to them the difference between a traditional English course and this project creating a tool to teach phonetics. I remember that two individuals did not want to participate at first because they believed they needed prior knowledge. They were afraid of phonetics, and I am sure that others were, too. The majority of the participants had totally ignored the existence of the phonetic component in the English language because teachers in my country usually teach grammar and vocabulary. As a result, it sounded new and interesting, too."

The motivation and attraction the students had for knowing something new was evident. On some occasions, innovation can cause anxiety, but the learners have shown the capability to develop language skills if given reasonable accommodations.

With regard to pedagogical development, the following three situations that occurred during training are good examples of those that suggested a positive effect of using the adaptive IPA symbols. One occurred in session four when the learners received the tactile cards and were asked to classify them based on the phonetic symbol each represented. Then they created the same symbols using pipe cleaners to demonstrate their knowledge of the form. In my diary I wrote, "This class was interesting because the learners designed their own material based on the symbols on the cards. As a blind person I know very well that if we model a figure by touching another one, we can understand the shape better."

In the above example, the three UDL principles are clear as follows:

a. Representation: The learners could identify the materials perfectly. The design was completely accessible. They could touch the symbol cards, recognize the shape of the figure, and some could read the Braille notation. (Recognition network)

b. Expression: The learners could create their own phonetic symbols using a very manageable and flexible material (i.e., the pipe cleaners). They could model the shape of the figures with their hands and touch the other classmates' symbols. In this way, they had input from two sources: the tactile cards and their own creations. (Strategic network)

c. Engagement: From the beginning, the participants were very interested in learning the symbols' shapes and modeling those shapes with another material. Not all of them had the same manual dexterity to model the shape with a pipe cleaner; however, they were always willing to participate. (Affective network)

Another situation that demonstrated the positive effect of the adaptive IPA symbols was in session six. The learners were using the unicode characters to type some phonetic transcriptions on the computer. In my diary, I wrote: "Before finishing the class, the learners were able to use the unicode characters to type the IPA symbols although some computers did not work very efficiently and many learners had problems typing the codes. A little confusion occurred with the diphthongs and some of the consonants requiring the participants to enter two characters (e.g., voiceless aspirated bilabial stop,

represented by a letter plus a superscript [p^h]). Although it was challenging, the majority of the learners could type phonetic symbols on the computer and write phonetic transcriptions".

We can apply the UDL framework to the above activity also:

a. Representation: The learners had an accessible website where they could search for the different unicode characters to type the corresponding phonetic symbols. This tool was also designed for use by sighted people as the software was the same (i.e., Doulos SIL fonts) so it is possible to describe it as universal (i.e., for everyone). Also on the website, the learners found the technical accommodation that screen readers needed to enable the program to recognize the characters and read their names. (Recognition network)

b. Expression: Although I chose the words the learners should type, they were able to use their own skills to memorize the four characters in each symbol's unicode. They typed the symbols using the conventional keyboard and they could understand the shape of the characters on the screen because of sufficient prior contact with them on the symbol cards. (Strategic network)

c. Engagement: Some learners had small difficulties with the computers; however, in general, most of them could type many words. Some opted for typing the code next to the word, to show that they tried to do the activity despite technical issues. (Affective network)

The last example that I would like to describe from my diary observation was in session seven: the Vowel Color Chart (Taylor & Thompson, 2012). This activity was quite ironic because the majority of the learners had never seen any color. However, I used the color chart to associate many common nouns that shared the same vowel as the name of the color (e.g., green tea). In my diary I wrote, "It was a very meaningful activity for everyone. I say that it is ironic because the majority of us do not recognize the colors, but the interesting result shows how the mind can associate one element with another even if it does not have a clear reference. That day, the students worked in groups as always when they developed any activity with the tactile cards. It was interesting to see how they disagreed about the possible color word. For me as a teacher, it is important to have evidence that students engage totally in the class and use

their own arguments to construct knowledge". The learners used the strategy of comparing sounds to try to find something similar in the word options they had. The UDL model also supports this development:

a. Representation: The learners could listen to an audio file to compare the different names of the colors and the words I proposed to match. They could also read the chart using the screen reader with English sounds. (Recognition network)

b. Expression: The learners worked in groups and were able to come to a consensus and persuade others to choose an answer. It was interesting to hear them use language in a different way although it was not always English because some of them were at a lower proficiency. The idea of them discussing an English word's pronunciation was a big goal for me as a teacher. With this activity, the important role of interaction was evident when the students worked together to try to find similarities between elements in the input. (Strategy network)

c. Engagement: The learners always showed a high level of motivation to participate. They were very excited trying to pronounce, repeat, and listen to the words to find the correct pair for each color name. (Affective network)

I now turn to some points from the second interview (translated from Spanish) that the participants completed after the training period. This interview gave me an opportunity to know their opinions, comments, suggestions, and achievements. The questions were related to self-reflection on a) the improvements in their listening and speaking skills, b) new strategies to practice the language, and c) their general perceptions of the course and the materials.

Post-Instruction Interview Comments (translated from Spanish). In terms of listening skill development, learners reported the importance of the following accomplishments that they had made over the training period:

a. Understood the difference in terminology between consonants and vowels.

b. Identified that the same grapheme can have different ways of being pronounced.

c. Recognized that this is a process under construction.

d. Experienced difficulties understanding different English accents.

e. Comprehended words when they were produced slowly; experienced difficulties when a speaker spoke quickly.

In general, perceptions were positive. All participants affirmed that they had improved their listening skills although they recognized they should practice more. In terms of speaking skill development, the learners reported the following accomplishments:

a. Developed more awareness about the position of the tongue, lips, and jaw when producing a sound.

b. Recognized the necessity of more practice.

c. Discovered that the amount of information they needed to learn required a longer training period.

d. Found that repeating the same sentence many times helped to produce the sound correctly.

In general, the perceptions were positive; however, as a teacher I recognize that I should implement more activities or practice time in the classroom to develop learners' speaking skills. They did not feel confident enough in their speech production.

Learners' Plans to Add New Strategies to Practice English. Learners reported that they planned to adopt the following strategies to continue to develop their English speaking skills:

a. Use the course material.

b. Pay more attention to songs and radio interviews.

c. Try to practice interacting with native speakers.

d. Listen to a song many times and repeat the lyrics to understand.

e. Use Duolingo.

f. Listen to international broadcasts and audios on the internet.

The majority of students said they were planning to continue developing their skills using diverse materials, including the website for this project although no specific frequency was mentioned.

Learners' General Comments on the Training. The learners provided the following comments on the training:

a. They needed more time (longer training period) to practice the sounds.

b. The instruction was good and clear.

c. The activities were suitable for understanding the differences among vowels, including monophthongs and diphthongs.

d. They wanted to have more tips on not giving up when it was difficult to understand.

e. A more homogeneous learner group was mentioned as a way for some to achieve greater improvement.

f. They requested creation of the same accessible scripts for other screen readers like NonVisual Desktop Access, a free open-source screen reader (by NV Access).

g. Some expressed an interest in having more practice exercises and less theoretical knowledge.

h. They also requested more exercises involving repetition to acquire the sounds.

i. Finally, there were also requests to develop this course for intermediate-level English learners to take more advantage of the topic.

In general, participants were disappointed that the course was not longer. All mentioned they felt they needed more time to understand and to practice. They wanted a deeper explanation of some symbols, and more audio material to reinforce the comprehension of the sound. In general, they were comfortable with the activities proposed by the teacher. The following participant comments concerned the IPA symbol cards:

a. They were great! I could understand the symbol!

b. The font for the symbols is confusing for people with low vision. Tahoma might be better.

c. It might be a good idea to make the cards also in a smaller size to join the pieces and form words like a puzzle.

d. Braille with "higher size" [greater tactual enhancement] for people with diabetes.[2]

e. Make a mark to indicate the correct position of the card. People who do not read Braille do not understand the correct way to hold the card.

In general, the students enjoyed using these tactile cards to learn the phonetic symbols. The design was very appropriate for their needs. Some of their suggestions were implemented in the design of 3D IPA symbol cards described later.

Learners' General Comments on the Website. Learners provided the following comments (translated from Spanish) about the website:

a. The website is perfect! I never had any problem listening to the audios.

b. It would be great if the website had the possibility of recording our voices repeating the sounds. We could receive a grade or motivating feedback to continue practice!

c. Provide some games related to phonetics.

d. Post more content on the website like grammar or vocabulary in addition to phonetics.

e. Change the colors on the website to improve the experience of low vision users. Also create tabs on the home page to go to the phonetic symbols instead of using a menu.

f. It would be great to have more audios with minimal pairs to learn better the differences between some sounds.

---

[2] Individuals with diabetic neuropathy may experience difficulty reading Braille. Studies have shown that participants with marked elevation of touch-perception thresholds in their fingertips may have difficulty feeling some type; in others, the difficulty may be related to an inability to perceive the individual points clearly (e.g., Heinrichs & Moorhouse, 1969).

The companion website provided excellent support for this project. It is completely accessible and it can be the first step in creating an ambitious plan to develop more courses with enough accessibility for all kinds of learners, even people with disabilities.

Finally, I present three examples of comments the students made at the end of the training process. These were chosen to demonstrate the variety of perspectives the participants showed toward this study. These comments and the answers from the second interview were the final feedback on this research. Each comment below appears in the original Spanish version followed by the English translation.

(1) Spanish version: Quiero felicitar a todos los que tienen que ver con este proyecto, la verdad me parece muy interesante y gratificante para mí crecimiento educativo y personal, me es muy ingenioso e interesante la forma de creación del material en físico y también a nivel virtual, la manera en la que nos instruye la profe Maritza y sus colaboradores.

Aunque todo esto ha sido nuevo para mi, hay tanto de lo que no conocía, ya que yo sé pronunciar, no sé qué tan bien lo haga siendo honesta, pero aprender el modo correcto de hacerlo va a ser muy chebere y sé que me servirá para un futuro.

Muchas gracias.

English translation: I want to congratulate all the people who are involved in this project. I think it has been very interesting and meaningful for my educational and personal background. For me, the way that the material was created physically and virtually was very innovative. I also like the instruction the teacher gives us in every class, and really now I realize how much I didn't know since all of this new knowledge was completely unknown to me. I believed I pronounced well, but now I know I should learn to pronounce correctly. It is going to be so exciting!

(2) Spanish version: Mi opinión referente a la metodología utilizada por la profe, me a parecido muy buena; la página web es muy completa, y las fichas son fáciles de detectar al tacto

English translation: My opinion about this project is very good. The website is so complete and the tactile cards are very easy to identify.

(3) Spanish version: Quisiera aportar una sugerencia, con respecto al examen final, que ya se acerca, siendo este, el mismo examen diagnóstico, dialogando con algunos compañeros, llegamos a la conclusión, que uno de los factores, que hizo mas difícil el examen diagnóstico, fue, el hecho de que unieran dos oraciones, primero la respuesta y después la pregunta, y nosotros teníamos que repetir solamente la respuesta, pero al escuchar la segunda frase, es decir, la pregunta, eso causaba una distracción, que dificultaba recordar la primera oración. Pues a mi modo de ver, creo que tal vez hubiera sido, mejor dejar una sola de las oraciones y realizar la repetición de esta.

English translation: I want to give one suggestion in regards to the final test. We know that is the same diagnostic exam and in the opinion of many classmates, we concluded that the most difficult for us in the pretest was the design. We believe that in the two sentences put together, the first was the answer and the second was the question; our development became more complex during the exam. We think that it could have been better just to listen to one sentence and repeat, and not two sentences because the first is a big distraction.[3]

Development of 3D Printed Cards

To address some of the issues raised by participants in their post-study feedback and in the interests of sustainability, the next stage in this project is to 3D print the IPA symbol cards. The process has begun. 3D printing is a common method used in other disciplines, such as engineering, as a way to make a *proof of concep*t model for testing a new mechanical device before building it in its final form (Kolitsky, 2014) or to create learning objects (Kostakis, Niaros, & Giotitsas, 2015). In its application to the visually impaired, it is challenging for them to study some objects in fields such as anatomy or in a

---

[3] Some participants did not understand the importance of reducing the possibility of imitation for research purposes by using the delayed repetition technique; yet, most of them had little difficulty.

science lab if the experience is only virtual. 3D printing, however, offers the opportunity to make the image-based structural component of a virtual or digital learning object into a real object that can be touched for a better learning experience (Jaquiss, 2012).

Figures 4 and 5 show the process of printing one of the 3D IPA symbol cards and the final product. Two different colors are used to enhance perception for low vision users. A smaller magnet can be adhered to the back of each card for use on a magnetic surface. This avoids accidental displacement but still permits the user to move it around to transcribe words.

Figure 4.

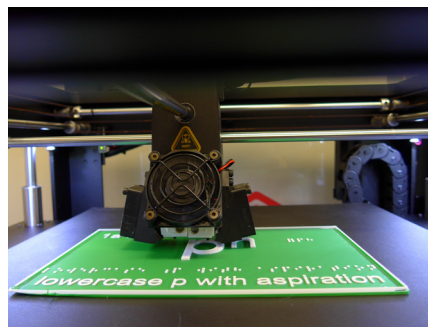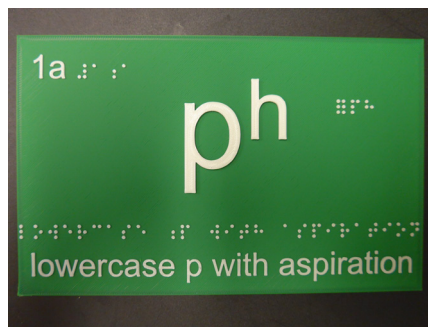*3D Production of the IPA Symbol Card for Aspirated /p/*

Figure 5.

Final 3D Symbol Card for Aspirated /p/

CHAPTER FOUR

General Discussion

The main objectives of this study were to create the components of ADEPT (Adaptive English Phonetic Tools): a) tactile IPA symbol cards, and b) a companion website to make IPA symbols accessible to blind and low vision learners of English, and to test its efficacy with an emphasis on American English vowels. The quantitative and qualitative outcomes have demonstrated improvement in phonetic awareness and pronunciation for L1 Spanish-speaking adult learners. The 10-week instructional period revealed that ADEPT had a positive effect. Posttest results showed significant improvement in learners' vowel pronunciation, and qualitative data revealed very positive feedback. Participants learned phonetic symbols, how to articulate American English sounds, and had opportunities to practice perception and production.

It is critical to recognize the importance of the Universal Design for Learning as a pedagogical framework that offers the possibility of thinking about the strengths and weaknesses of all students in general. This model allows teachers to understand that the idea of teaching and learning for all people involves all communities at the same time. It is not necessary to create a special distinction or a segregated environment in order to support the learning process of vulnerable populations such as disabled students. The real impact in this study is that the research team accomplished the goal of creating a didactic tool that could solve some instructional problems that EFL teachers have had in their attempts to teach phonetics and American English sounds to students with visual impairments. The design and presentation of ADEPT to the disabled community in Colombia was the biggest outcome of this research. As an English teacher I was able to demonstrate the relevance of the creation of such educational resources which can innovate the EFL classrooms of the world. Students with disabilities and the general learning community can access the website and instructions to create the tactile materials. The UDL principles of representation, expression, and engagement became essential elements in this study in the design of each activity during the training, which achieved its goals.

The current project was implemented following the three UDL principles described earlier. The recognition network was incorporated through the development of the materials (the IPA symbol cards and the companion website), permitting the students to identify the symbols and their most important characteristics. The strategic network was addressed through the 10-week phonetic training period, during which, the learners were provided with multiple activities that introduced the basic concepts of and perceptions about phonetics. The affective network that was related to learner engagement emerged through interaction among learners and between learners and the materials.

The findings of the current study broaden our understanding of multisensory learning to include tactile information. Importantly, learners not only felt the symbols that represent the IPA, but reproduced them manually with pipe cleaners, and used them in conjunction with auditory information from the instructor, other learners, and the website to practice their new perception and production skills. The participants responded well to the materials developed for the study but wanted more practice. In particular, more interaction among the participants would likely have been beneficial as they had developed supportive communities within the larger group.

During the training period, participants worked in teams during all sessions. Each group of about four participants worked with a set of IPA symbol cards, and all had access to computers to accommodate practice typing IPA symbols and using the website designed for the study. These activities emphasized the value of collaborative learning. Some participants were designated as leaders in their corresponding groups. The leader was the most skilled learner in terms of digital literacy, Braille skills, and previous experience with the English language so this individual was able to generate a supportive community for the other group members, which contributed so much to their learning process. This interactive environment was a good example of the construction of a collaborative learning environment in a language classroom to allow each learner to reach full potential.

Their identities as non-native English speakers played an important role with regard to their motivation to take part in the study. Their desire to have better professional opportunities, to have contact

with people from other cultures, to improve their level of comprehension to enhance their enjoyment of music and movies were important factors that allowed all of them to engage fully with the learning process and to demonstrate improvement in their abilities following the training period.

Some limitations arose in the study and with regard to the materials and their implementation. The participants wanted more time to explore, recognize, understand, and learn all 45 IPA symbols chosen for this study. In addition, the design of the symbol cards required a special printer which is not easy to find in Colombia or in some other countries. Many of the participants in the study did not have computers at home so their practice time was limited to the weekly sessions on campus. More opportunities were needed to allow learners to practice their English skills. This is often a challenge in countries in which English is not spoken on a daily basis outside the classroom. In addition, more interactive activities would take this approach to the next stage, especially given how well the groups functioned as individual learning communities. From a technical perspective, the scripts that were created to enable the software JAWS for Windows to navigate the website easily and allow the reading of the names of the IPA symbols were temporarily installed in the software. Unfortunately, that meant that they disappeared when software updates occurred. If the manufacturer allowed a more permanent installation in the program, it would avoid the need to re-install them after each update. The swell (thermal) paper on the magnets to create the tactile cards was a good option; however any paper product will deteriorate from excessive use over time. Therefore, 3D printing is a solution for sustainability.

Conclusion

The teaching of language is similar across all kinds of students. Disabilities are not obstacles to language learning with good materials and instructional methods that provide an inclusive ESL or EFL classroom. Multisensory input, whether a combination of auditory, visual, and/or tactual, enriches language acquisition as do cooperative learning environments and the process of empowering learners by giving them a true sense of the purpose of learning another language. Importantly, the learners in the current study were able to participate in an empowering process through the training. Their lists of

suggestions, comments, and reflections made me think that they had found in this study not only the opportunity to learn about phonetics but the awareness that they could discover other types of knowledge with some curricular accommodation. Their active participation and their strong enthusiasm throughout the study were proof of their eagerness to learn. In this case, it was evident that the learning process had been successful with the support of good materials and instruction.

Language teachers everywhere can encourage in their classrooms the relevance of phonetic study to improve oral skills in any language and the importance of cooperative learning to incorporate a true environment of inclusive education.

APPENDICES

APPENDIX A: Technical Details

To use the IPA phonetic fonts with JAWS for Windows on a Windows 10 computer:

1. Download IPA phonetic fonts from https://software.sil.org/doulos/download/ and install them.

2. To enable JAWS to read or describe IPA symbols for a user, a dictionary of the codes and the symbols must be installed in the JAWS SBL file. Instructions for this are on the website and are available at http://www.ruf.rice.edu/~reng/jaws-ipa.html.

In addition, on the companion website, there is a downloadable file with the IPA symbols in Braille. This manual is authorized by the International Council on English Braille (ICEB) and is also available on its website: http://www.iceb.org/.

The following questions were sent in Spanish to the study's participants. The first set (1-6) was sent prior to the 10-week instructional period. The second set was sent following instruction.

Pre-Instruction

1. What are the most difficult aspects of English pronunciation for you?
2. How do you usually study or practice English listening and pronunciation?
3. On average, how often do you listen to English during a week (e.g., English media)?
4. Do you listen mostly to American English or other varieties of English (e.g., British)?
5. In what ways do you try to improve your English skills? Examples:
    a. Listening to music with lyrics in English
    b. Listening to various websites (e.g., YouTube, websites designed for English practice)
    c. Listening to TV, films, audio materials related to books in English
    d. Paying special attention to specific sounds
    e. Repeating after native speakers of English (e.g., shadowing speakers on recordings, TV)
    f. Speaking with other people in English
    g. Asking other people to give you feedback on your pronunciation
6. Do you have a special goal in improving listening and speaking skills in English?

Post-Instruction

7. Do you think your listening skills have improved as a result of the instruction?
8. Do you think your speaking skills have improved as a result of the instruction?
9. Are you thinking of changing any listening or speaking strategies as a result of the instruction?
10. Do you have any suggestions for the improvement of the instruction that you received?
11. Do you have any suggestions for the improvement of the materials (tactual cards and website) that you used?

REFERENCES

REFERENCES

CAST (2018). Universal Design for Learning Guidelines version 2.2.
http://udlguidelines.cast.org

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Dale, P., & Poms, L. (2005). *English pronunciation made simple*. White Plains, NY: Pearson.

Duxbury Systems, Inc. (2019). Duxbury Braille Translator. https://www.duxburysystems.com/

Englebretson, R. (2009). An overview of IPA Braille: An updated tactile representation of the International Phonetic Alphabet. *Journal of the International Phonetic Association, 39(1),* 67-86.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics* (5th ed.). Thousand Oaks, CA: Sage.

Flege, J. E. (2003). Assessing constraints on second-language segmental production and perception. In A. Meyer, & N. Schiller (Eds.), *Phonetics and phonology in language comprehension and production: Differences and similarities* (pp. 319-355). Berlin: de Gruyter.

Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. In W. Strange (Ed.), *Speech perception and linguistic experience: Theoretical and methodological issues* (pp. 233-277). Timonium, MD: York Press.

Flege, J. E., Munro, M. J., & MacKay, I. R. A. (1995). Factors affecting strength of perceived foreign accent in a second language. *Journal of the Acoustical Society of America, 97(5),* 3125–3134.

Freedom Scientific. (2019). JAWS for Windows.
https://support.freedomscientific.com/Products/Blindness/JAWSdocumentation

Gass, S. M., & Mackey, M. (2015). Input, interaction, and output in second language acquisition. In B. VanPatten, & J. Williams (Eds.), *Theories in second language acquisition: An introduction* (pp. 180-206). New York: Routledge.

Gick, B., Jóhannsdóttir, K. M., Gibraiel, D., & Mühlbauer, J. (2008). Tactile enhancement of auditory and visual speech perception in untrained perceivers. *Journal of the Acoustical Society of America, 123(4)*, EL72-76.

Hardison, D. M. (2003). Acquisition of second-language speech: Effects of visual cues, context, and talker variability. *Applied Psycholinguistics, 24,* 495-522.

Hardison, D. M. (2012). Second language speech perception: A cross-disciplinary perspective on challenges and accomplishments. In S. M. Gass & A. Mackey (Eds.), *The Routledge Handbook of Second Language Acquisition* (pp. 349-363). New York: Routledge.

Hardison, D. M. (2014). Phonological literacy in L2 learning and teacher training. In J. Levis & A. Moyer (Eds.), *Social dynamics in second language accent* (pp. 195-218). Boston/Berlin: de Gruyter Mouton.

Heinrichs, R. W., & Moorhouse, J. A. (1969). Touch-perception thresholds in blind diabetic subjects in relation to the reading of Braille type. *The New England Journal of Medicine, 280,* 72-75.

Jaquiss, Robert (2012). Advanced technology for producing tactile materials. *Braille Monitor,* 55(4). https://nfb.org/images/nfb/publications/bm/bm12/bm1204/bm120407.htm.

Kanno, Y., & Norton, B. (2003). Imagined communities and educational possibilities: Introduction. *Journal of Language, Identity, and Education, 2,* 241-29.

Kolitsky, M. A. (2014). 3D printed tactile learning objects: Proof of concept. *Journal of Blindness Innovation and Research, 4(1)*. https://www.nfb.org/images/nfb/publications/jbir/jbir14/jbir040102.html.

Kostakis, V., Niaros, V., & Giotitsas, C. (2015). Open source 3D printing as a means of learning: An educational experiment in two high schools in Greece. *Telematics and Informatics*, 32, 118-128.

Ladefoged, P., & Disner, S.F. (2012). *Vowels and consonants* (3rd ed.). Malden, MA: Wiley-Blackwell.

Lantolf, J. P., Thorne, S. L., & Poehner, M. (2015). Sociocultural theory and second language learning. In B. VanPatten, & J. Williams (Eds.), *Theories in second language acquisition: An introduction* (2nd ed.) (pp. 207-226). New York: Routledge.

Levis, J. M. (2005). Changing contexts and shifting paradigms in pronunciation teaching. *TESOL Quarterly, 39, 369-377.*

Lillehaugen, B. D., Echavarría Moats, G., Gillen, D., Peters, E., & Schwartz, R. (2014). A tactile IPA magnet-board system: A tool for blind and visually impaired students in phonetics and phonology classrooms. *Language, 90(4),* e274-e283.

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods*, 7, 105-125.

The National Federation of the Blind Jernigan Institute. (2009). *The Braille literacy crisis in America: Facing the truth, reversing the trend, empowering the blind*. https://www.nfb.org/images/nfb/documents/pdf/braille_literacy_report_web.pdf

Orsini-Jones, M. (2009). Measures for inclusion: Coping with the challenge of visual impairment and blindness in university undergraduate level language learning. *Support for Learning, 24(1),* 27-32.

Orsini-Jones, M., Courtney, K., & Dickinson, A. (2005). Supporting foreign language learning for a blind student: A case study from Coventry University. *Support for Learning, 20(3),* 146-152.

Pavlenko, A., & Norton, B. (2007). Imagined communities, identity, and English language learning. In J. Cummins, & C. Davison (Eds.), *International handbook of English language teaching* (pp. 669-680). New York: Springer.

Pullum, G. K., & Ladusaw, W. A. (1996). *Phonetic symbol guide* (2nd ed.). Chicago: The University of Chicago Press.

Rose, D. (2012, February 13). *Braille is spreading but who's using it?* BBC News. https://www.bbc.com/news/magazine-16984742

Rose, D. H., Meyer, A., & Hitchcock, C. (Eds.) (2005). *The universally designed classroom: Accessible curriculum and digital technologies*. Cambridge, MA: Harvard University Press.

Sato, M., Cavé, C., Ménard, L., & Brasseur, A. (2010). Auditory-tactile speech perception in congenitally blind and sighted adults. *Neuropsychologia, 48,* 3683–3686.

Shams, L., & Seitz, A. R. (2008). Benefits of multisensory learning. *Trends in Cognitive Sciences, 12(11)*, 411-417.

Supalo, C. A., Mallouk, T. E., Rankel, L., Amorosi, C., & Graybill, C. M. (2008). Low-cost laboratory adaptations for precollege students who are blind or visually impaired. *Journal of Chemical Education, 85*(2), 243-247.

Taylor, K., & Thompson, S. (2012). *Color vowel chart*. Santa Fe, NM: English Language Training Solutions. https://americanenglish.state.gov/resources/color-vowel-chart

US Department of Education (2008). *Higher Education Opportunity Act – 2008*. https://www2.ed.gov/policy/highered/leg/hea08/index.html

Web Content Accessibility Guidelines 2.0, W3C World Wide Web Consortium Recommendation. Latest version at http://www.w3.org/TR/WCAG20/

Wells-Jensen, S. (2005). The Braille International Phonetic Alphabet and other options: The blind student in the phonetics classroom. *Journal of the International Phonetic Association, 34(2),* 221-230.