Computer-Assisted Pronunciation Training (CAPT): An empirical evaluation of EPSS Multimedia Lab

María de los Ángeles Gómez González, University of Santiago de Compostela
Alfonso Lago Ferreiro, University of Vigo

Abstract

Previous research has established that phonetics has been marginalized within language teaching, proving to be particularly challenging for learners in EFL contexts. This paper presents EPSSML (https://www.usc.gal/multimlab/), an e-learning platform designed within Mayer’s (2008, 2009) Cognitive Theory of Multimedia Learning to instruct English phonetics and phonology in an EFL context. Inspired by prior work (e.g., Clark, 2009; Godwin-Jones, 2009; Hansen Edwards et al., 2021), we examined the efficiency of EPSSML as a Computer Assisted Pronunciation Training (CAPT) resource alongside the students’ perceptions of it including gender differences. The scores obtained by 504 Spanish EFL learners in an English phonetics undergraduate course were analyzed comparing performance before and after EPSSML-assisted instruction. The analysis of rated results shows that there is a significant difference between the means of scores of those learners that used and those that did not use the platform, as well as between male and female students. Additionally, 127 students that used EPSSML responded to an online questionnaire on the tool and course methodology. Responses reveal that 91.3% of the learners enjoyed and were very interested in EPSSML and web-mediated phonetic training. The findings demonstrate the importance of CAPT-based instruction and suggestions are also made for additional resources and approaches for its implementation, thereby contributing to the educational shift from traditional, teacher-centered learning methods to blended instructional methodologies in formal and informal settings.

Keywords: Computer Assisted Pronunciation Training, EFL Phonetics Web-Mediated Learning, Phonetic Skills, Contrastive Phonetics

Language(s) Learned in This Study: English


Introduction and Literature Review

The development of phonetic and phonological competence is a crucial component in the acquisition of a second language. According to the Common European Framework of Reference for Languages, phonological competence refers to the knowledge of and skill in the perception (receptive) and production (productive) of sounds and prosodic features like stress, rhythm, and intonation, including such related features as accentedness (i.e., accent and deviation from a “norm”), intelligibility (i.e., the accessibility of meaning for interlocutors, as well as their perceived difficulty in understanding or “comprehensibility”), and phonetic accuracy or precision (Common European Framework of Reference [CEFR], 2020, p. 134, p. 261). Foreign language phonetic competence, on the other hand, is a multidimensional concept that determines the success or failure of verbal interaction in the context of intercultural communication involving declarative knowledge and awareness of specific phonetic and phonological aspects of language(s) (L2 or any other language, including the L1), as well as phonetic skills such as the perception, production, and transcription of speech (Borysko, 2011; Gurova et al., 2020).

Aspects of phonetic competence not only have an impact, to varying degrees, on the four main language
skills (i.e., listening, speaking, writing, and reading), they are also essential for intelligible and comprehensible speech in any situation or domain (Underhill, 2013). Native speakers can decode the utterances of non-native speakers when the latter pronounce appropriately, even if their grammar and vocabulary are less than accurate (Levis, 2018; Pourhosein Gilakjani, 2016). Furthermore, phonetic errors or mispronunciations may give rise to native speakers’ judgmental attitudes (Anderson-Hsieh & Koehler, 1988) and distraction or irritation on the part of addressees (Fayer & Krasinski, 1987), as well as to negative stereotypes about speakers’ status (Seidlhofer, 2001), lack of credibility (Lev-Ari & Keysar, 2010), or even the avoidance of interactions with disfluent speakers (Singleton, 1995).

Given its importance, English phonetics instruction should be a central component of teaching English as a Foreign Language/International Language/Lingua Franca (EFL, EIL, ELF). However, research suggests that phonetic training is often neglected in EFL/EIL/ELF classes, compared to reading, writing, grammar, or vocabulary (e.g., Cruttenden, 2014; Kelly, 1969; Underhill, 2013). Among the factors mentioned to explain this are that fluency and intelligibility are prioritized over phonetic accuracy, particularly in communicative second language classes (Baker & Burri, 2016; Foote et al., 2016; Levis, 2018) or that phonetic content is difficult for students (Bakla & Demirezen, 2018; Stevick et al., 1975). Pronunciation, phonology, or phonetics are issues normally targeted in the upper-level specialized courses, so learners may not be exposed to systematic phonetic and pronunciation training until late in their language learning process (Ducate & Lomicka, 2009). Other reasons given include that EFL/EIL/ELF teachers often lack enough phonetic training in certain areas that consequently are either taught ineffectively or not taught at all (Derwing & Munro, 2005; Gregory, 2005; Hismanoglu, 2012; Szpyra-Kozlowska, 2015), alongside the lack of class time or suitable materials adapted to learners’ needs (Henderson et al., 2015; Macdonald, 2002; Munro & Derwing, 2007). This is exacerbated by the fact that phonetic competence involves not only cognitive (Fraser, 2006) but also perceptual (Flege, 1995; Kuhl & Iverson, 1995) and psychomotor abilities (Leather & James, 1991) that vary from one individual to another, and which ultimately require explicit instruction.

In the wake of the information explosion and rapidly progressing technology, Computer-Assisted Language Learning (CALL) and, specifically, Computer-Assisted Pronunciation Training (CAPT) have developed massively in recent decades (Calvo Benzies, 2017; Fouz González, 2015; Setter, 2008; Walker, 2014). As a result, there has been a recent proliferation of resources for phonetic instruction that can be grouped into the following four main categories, which are further exemplified in Table 1 (Appendix A) with corresponding websites:

1. **CAPT01**: e-books (including online dictionaries), websites, blogs, and tutorials produced by experts in English phonetics (e.g., John Wells, Peter Roach, Peter Ladefoged) or authorized institutions (such as BBC or the British Council).

2. **CAPT02**: Software and programs related to phonetic transcription (e.g., PhoTransEdit, Lingorado, IPA Online Keyboard), audio editing software (e.g., Audacity, Wave Pad), Speech Recognition Technology (SRT) (e.g., Voice to Text Pro, Twilio Voice, Just Press Record, Google Cloud Speech to Text), Text-To-Speech conversion systems (TTS) that use synthetic speech, and acoustic analysis software such as Praat and Automatic Speech Recognition (ASR) technology (e.g., Dragon Anywhere, Says, Swype, Tell Me More) that may be applied to evaluate learners’ production and offer feedback on their performance.

3. **CAPT03**: Mobile-assisted Language Learning (MALL) or mobile learning (m-learning) using hand-held devices and applications (apps) such as Elsa-Speak, among others.

4. **CAPT04**: More generally, any type of digital audio-visual materials (e.g., podcasts, social network services, music, original versions of movies, mass media) that are used as CAPT tools in phonetic training.

Mainstream experimental research underscores the effectiveness of CAPT tools and systems for phonetic
training on such aspects as production and perception of L2 sounds/phonemes (e.g., Fouz González 2015, 2020; Kim, 2012; Ducate & Lomicka, 2009; Luo, 2016; Mompean & Fouz González, 2016), rhythm and stress (Coniam, 2002), intonation (Cauldwell, 2012; Hardison, 2004; Levis & Pickering, 2004), and speech rate and fluency (Hincks, 2005). These studies generally conclude that learners who use CAPT materials improve their phonetic/phonological awareness (Fouz González, 2020; Lively et al., 1994), as well as their perceptive and/or productive (supra)segmental skills in comparison to their control groups, thereby also increasing their academic achievements and learning motivation (Jensen-Lee & Falahay, 2002; Loucky, 2005; Stepp-Greany, 2002; Suarcaya, 2008). Additionally, other investigators have discussed the superiority and feasibility of applying CAPT to impart English phonetic content in class (Bu, 2003; Luo, 2016; Sha 2005) and/or their findings have revealed strong positive perceptions from either teachers or students of the usefulness and motivation potential of specific CAPT tools (Baker & Burri 2016; Stepp-Greany, 2002; Yang, 2022).

Although such prior research confirms the affordances of technology for language learning in general and phonetic training in particular, some investigations raise a number of problematic issues. A common criticism is that many CAPT resources lack the solid pedagogical underpinnings required to ensure effective learning, either because they have been developed with commercial success in mind (Hansen, 2006) or because they appear to be technology-driven rather than pedagogy-led. It has been claimed that CAPT resources frequently provide generalized content and feedback rather than individualized support for learners (Derwing & Munro, 2015) or that they offer inaccurate, simplistic, or even erroneous descriptions of phonological features, statements of rules, or feedback, thereby frustrating, demotivating or misinforming learners (Rogerson-Revell, 2021). Furthermore, while specific investigations have found no differences for blended instruction1 (Delialioglu & Yildirim, 2008; Lim et al., 2007; Napier et al., 2011), other empirical studies have revealed that a higher percentage of students drop or fail online and blended courses compared to face-to-face training due to their lack of online skills and effective learning strategies (Colferai & Gregory, 2015; Levy, 2007; Stracke, 2007). Along similar lines, in yet other contributions students are reported to prefer paper materials to computer tutorials for their ease of use as compared to problems occurring when using the software, web browsers, or online resources (Jarvis & Szymczyk, 2010; Jensen et al., 2015).

Putting on a “gender lens,” in almost all countries there exists a gender divide with respect to digital skills (United Nations University, 2019) reportedly because of the issues women face in life (e.g., pregnancy and motherhood, sexist stereotypes, cultural barriers, or male-dominated jobs, among others). Many studies address the topic of gender bias and sexism in language (Menegatti, 2017), while, in education, there exist diverting claims for pedagogical framings (e.g., textbooks, articles, and other curricular materials) perpetuating male as a default (Lee, 2018a, 2018b) or decreasing the gender bias (Lewandowski, 2014). Likewise, it has been argued that female students generally underperform on computer technology competencies (Adedapo, 2020; McNeese et al., 2003). Such differences have been attributed to the ability of males to concentrate for longer hours while using computers, that males may have a better attention span, and the fact that females prefer a different type of learning. By contrast, other studies assume a language learning advantage for females (Piske et al., 2001), while alternative views suggest that it is not biological sex that has an impact on L2 (phonetics/pronunciation) learning, but rather the social differences related to gender-specific norms and a desire to accommodate to L1 and L2 male or female speech (Hansen Edwards et al., 2021).

Despite conflicting results and views, little or nothing is known about studies that have used a combination of course-wise performance and gender in examining achievement differences in CAPT-mediated instruction while simultaneously eliciting the users’ perceptions with the purpose of determining not only whether such resources have solid pedagogical underpinnings to ensure effective learning, but also to see if they uncover a gender breach. This article aims at contributing to fill this gap in a three-fold manner. First, as suggested by Godwin-Jones (2009), it intends to determine whether web-mediated, blended EFL phonetic instruction in comparison to traditional teacher-centered instruction (TCI) (Whitton et al., 2010) allows students to improve their results in an English phonetics and phonology undergraduate course in
Spain. Therefore, the study deviates from mainstream CAPT research which generally administers pre- and post-phonetic training tests to an experimental group comparing results with those of a control group. Second, it assesses the pedagogical adequacy and challenges of EPSSML-based instruction by disclosing and discussing students’ academic results and perceptions. And third, the gender implications of the type of instruction under inspection are also examined. Accordingly, three research questions will be addressed:

RQ1  Is the CAPT01 website “English Pronunciation for Speakers of Spanish Multimedia Lab” (EPSSML) an effective resource to teach English phonetics and phonology (to Spanish EFL) in a blended environment?

RQ2  What are the (Spanish EFL) students’ attitudes towards EPSSML-mediated, blended EFL phonetic instruction?

RQ3  Are there any gender-based differences regarding RQ1 and RQ2?

Our research questions are integrated within what Clark (2009) calls “situated research” for the creation and evaluation of multimedia-based materials and practices involving four dimensions. Consequently, we shall see that EPSSML (a) addresses a specific problem of practice; (b) reflects the norms and culture of the implementing institution and its context of influence, from which generalizations can be made; (c) utilizes validated methods and research designs; and (d) is grounded in theory (Developing EPSSML section). After providing the data and methodology (Experiment Design section), the empirical evidence used to answer these three research questions is presented (Results section) and discussed (Discussion of results section), followed by the main conclusions of the survey.

Case Study: An Empirical Evaluation of EPSSML-Mediated EFL Phonetic Instruction

Developing EPSSML

Spain is no exception to the general trend already outlined. Despite the importance attributed to EFL phonetics by both teachers and students (e.g., Calvo Benzies, 2016; Castillo Rodríguez et al., 2023; Cenoz & García-Lecumberri, 1999; Díaz Lage et al., 2023; Walker, 1999), aspects of phonetic competence have proved to be hard to acquire by secondary and university Spanish-speaking learners of English (SSLE) according to several international comparative studies such as PISA, The European Survey on Language Competences, and other empirical work (e.g., Alonso, 2014; Martínez Flor et al., 2006; Alonso, 2014; Szpyra-Kozłowska, 2015). In addition to personal, perceptual, cognitive, affective, and acculturation variables (i.e., degree of social/psychological interaction with the target group) (Gallardo del Puerto et al., 2009; Schumann, 1986), other reasons adduced are the application of allegedly inadequate methodologies (Calvo Benzies, 2016; Chela Flores, 2008) or the negative interference of the native language, given the disparities existing between Spanish (a Romance, syllable-timed language) and English (a Germanic, stress-timed language) in terms of sounds, prosody, accent variation, and spellings (Derwing & Munro, 2005; Estebas Vilaplana, 2009; Finch & Lira, 1982). As a result of these factors, SSLE reportedly perform better in grammar, vocabulary, reading, or writing than in phonetic tasks and skills (Bartolí Rigol, 2005; Martínez Adrián & Gallardo, 2011).

To contribute to the reversal of this situation, EPSSML (https://www.usc.gal/multimlab/) was created as an open-access website to attain the seven CEFR general (GC) and specific (SC) competencies detailed in Table 2 below, associated with the goals of a one-semester second-year English Phonetics and Phonology course of the English Language and Literature degree at the University of Santiago de Compostela (Spain) to train experts in English and the English-speaking cultural area. The course is designed to acquire analytical awareness and conceptual precision on English phonetics and phonology, and simultaneously to train phonetic skills2, primarily the perception and transcription of the sound system and prosody of Received Pronunciation (RP), which is the accent of reference in most EFL textbooks and materials, especially in Europe, although phonetic variation is also addressed.
To devise EPSSML, we adopted a collaborative approach in which phonetics educators and other EFL instructors worked together with our team to meet students’ needs and improve classroom practice. These collaborative efforts and feedback followed Mayer’s (2008, 2009) Cognitive Theory of Multimedia Learning (CTML) empirically validated instructional design principles that served as a learner-oriented guide to instructional design to reduce extraneous cognitive load while maximizing active cognitive processes. Table 3 below represents a checklist of the EPSSML design principles linking to Mayer’s CTML alongside their effect sizes as reported by Mayer (2008). The contents of EPSSML can be accessed both online and offline (Gómez González & Sánchez Roura, 2016; Gómez González et al., 2017, 2021) and they have been especially devised for SSLE. In addition to other phonetic and phonological issues, EPSSML pays particular attention to phonetic transcription training, as well as to the areas that are potentially most difficult for SSLE according to several L2 speech models. Prior work has shown the effectiveness of using International Phonetic Alphabet (IPA) symbols in the acquisition of L2 phonetic competence (Fouz González & Mompean, 2021; Lintunen, 2004; Mompean & Fouz González, 2021; Mompean & Lintunen, 2015). Additionally, the architecture of EPSSML underpins the Perceptual Assimilation Model (PAM) rationale that native-language/second-language perceptual similarity acts as a predictor of difficulties in the discrimination of non-native contrasts (Best & Tyler, 2007), in combination with the Speech Learning Model (SLM) assumption that patterns of learning are predictable from assimilation of L2 sounds to L1 ones so that listening perception through L1 and L2 perceptual representations should be operationalized to highlight phonetic awareness both in L1 and L2 (Flege & Bohn, 2021). Allophonic variation (context- and accent-specific) across different talkers with different voices and speech patterns is also addressed (Table 3).
**Linkage of EPSSML Design Principles to Mayer’s (2008, 2009) CTML**

<table>
<thead>
<tr>
<th>Research-Based Instructional Design Principles and Effect Sizes</th>
<th>Linkage to Mayer’s Instructional Design Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coherence Principle (ES = .97)</td>
<td>Each EPSSML heading only contains information relevant to the concept being presented</td>
</tr>
<tr>
<td>Signaling Principle (ES = .52)</td>
<td>Each EPSSML heading contains recurring explicit cues to signal the beginning of a new section (e.g., mnemonic, visual, or conceptual cue)</td>
</tr>
<tr>
<td>Redundancy Principle (ES = .72)</td>
<td>Each EPSSML heading contains carefully selected key information</td>
</tr>
<tr>
<td>Spatial Contiguity Principle (ES = 1.12)</td>
<td>The on-screen text and pictures in each EPSSML heading are presented in close proximity to one another</td>
</tr>
<tr>
<td>Temporal Contiguity Principle (ES = 1.31)</td>
<td>Pictures and texts correspond to the audio material</td>
</tr>
<tr>
<td>Modality Principle (ES = 1.02)</td>
<td>EPSSML contents are multimodal interspersing texts and audio-visual materials to attain the objective pursued</td>
</tr>
<tr>
<td>Segmenting Principle (ES = .98)</td>
<td>The main ideas are segmented into separate headings and activities, and audio-video material can be paused by users at any time</td>
</tr>
<tr>
<td>Pretraining Principle (ES = .85)</td>
<td>The contents are preceded by explicit statements of purpose explaining the rationale behind the activities and challenges</td>
</tr>
<tr>
<td>Multimedia Principle (ES = 1.39)</td>
<td>The contents of EPSSML are multimedia, so this principle is applied</td>
</tr>
<tr>
<td>Personalization, Voice, and Image Principles (ES = 1.11)</td>
<td>The contents of EPSSML are narrated in a conversational style by one female speaker of Peninsular Spanish and five native speakers of RP (three female and two male), in addition to other voices to represent additional English accents (Resources - UNIT 1 – Accents in English). The images of two speakers are on the screen. The icons and images are non-abstract and easily recognizable by viewers.</td>
</tr>
</tbody>
</table>

In this way, SSLE do not focus on one single pronunciation model, but rather are exposed to different allophonic realizations and accents—at least in terms of listening/speech perception and transcription—with the aim of raising awareness of phonetic variation while simultaneously developing L2 speech perception skills, as demonstrated in High Variability Phonetic Training (HVPT) research (Carrie, 2016; Mompean, 2004; Mompean & Fouz González, 2021). Accordingly, EPSSML adopts a contrastive RP-Peninsular Spanish (PSp) (or Standard European Spanish) perspective. In the Sound Bank tab (Figure 1), the IPA phonetic symbols corresponding to the sounds of...
RP (49) are displayed on a keyboard to be contrasted with those of PSp (42). When one RP sound is selected, a window opens, contrasting that sound on the left with its closest equivalent(s) in PSp, if any, on the right. The Sound Bank displays their phonetic symbols, identification labels, articulatory descriptions, and animated mid-sagittal sections of the oral chamber alongside videos of a frontal view of the mouth movements of a male and a female native speaker of RP and PSp, respectively. The speakers showcase the pronunciation and transcription of sounds in different phonetic contexts, both in individual words and in longer sequences. The benefits of this kind of bimodal input through the auditory and visual channels including two-dimensional (2D) and three-dimensional (3D) computer animations of the lips and oral cavity alongside a frontal view of the face have been consistently confirmed in previous studies, particularly to demonstrate external articulators—lips—as well as the internal movements of the tongue and other internal articulators (Badin et al., 2010; Hazan & Li, 2008)

**Figure 1**

*EPSSML Sound Bank and Interface*
Pronunciation from Spelling (and Vice Versa). These tabs are complemented by a search tool to ease navigation and find key terms.

To round off this section, it should be emphasized that the EPSSML phonetic training materials have been devised and selected adopting a holistic multimodal perspective (Szpyra-Kozłowska, 2015). This means that, while traditional phonetic training is generally just based on imitation tasks and is mainly suitable for auditory learners who are capable of listening and imitating the target language sounds and prosody without the intervention of any explicit information, EPSSML caters to students’ different learning styles by combining four different kinds of explicit training:

1. **auditory**, involving sound discrimination and contrastive tasks across different pronunciation models in order to improve comprehension of English accents.

2. **articulatory**, by using different types of drills (e.g., minimal pairs [word-level and sentence-level drills], contextualized minimal pairs, and tongue twisters) interspersed with real-life communicative pronunciation activities.

3. **cognitive**, in the case of (usually problem solving) tasks linked to reflection and feedback sessions, which have been devised to enhance learners’ understanding of the basics of L1 and L2 phonetics and phonology (including transcription skills or sound-phonetic symbol-spelling mappings) through developing their phonetic metacompetence and raising their phonological awareness.

4. **multisensory**, by integrating different kinds of multisensory reinforcement: auditory (e.g., ear training), visual (e.g., phonemic transcription and other kinds of visual aids such as sound charts, diagrams, or head cross-sections), and kinesthetic (by suggesting games, props, drama, or role play activities suited to this learning style, as will be further explained in the Discussion of Results section).

Although these kinds of explicit training are well-known and have been presented separately in different publications on English phonodidactics, another of the novelties of EPPSML resides in the integration of these four kinds of instructional styles into a coherent model for developing and delivering EFL phonetic instruction, as has been explained so far.

**Experiment Design**

**Data and Participants**

We examined the results (including first exams and resits) obtained by 504 undergraduates ($N = 504$), generally aged 19 years and with a B2 (upper intermediate) level of English, in the English Phonetics and Phonology course already described. The samples were divided into two datasets: Pre- and Post-EPSSML. Pre-EPSSML contained the course scores obtained by 228 students, 181 females and 47 males, who took the course in a two-year time span (2014–2016) before the CAPT tool under inspection was implemented in the course. Post-EPSSML included the grades of 276 learners, 223 females and 53 males, who were instructed with EPSSML over a similar period (2017–2019). Additionally, 127 (57%) students of the Post-EPSSML group, 116 females and 11 males, volunteered to answer a questionnaire about their perceptions of EPSSML and web-mediated blended phonetic instruction. Participants were neither paid nor given any additional credit, and none reported any hearing or language impairments.

**Instrumentation**

Pre-EPSSML and Post-EPSSML results were classified in terms of a three-value scale—PASS, FAIL, and NO SHOW—in order to avoid data dispersion, although percentages for the complete grading system used in the course were also considered. The survey measured students’ performance on three different types of tests (sampled in Appendix B) on expository, seminar, and lab instruction during one semester along four consecutive academic years. The tests’ contents were reviewed, validated, and assessed by the same instructors (including one of the authors) to check for potential bias or inequalities in teaching methodologies over the years under evaluation. The expositive sessions test (50% of the overall score) evaluated knowledge-based English phonetic and phonological analysis through such assessment items as...
multiple-choice questions, practical tasks, and essays, as is common practice in the teaching context under study. The interactive sessions test (30% of the final mark) focused on transcription skills including performance-based items based on written stimuli, that is, correspondences between spelling and phonetic notation in direct and reversed transcription practice. Lastly, the lab test (20% of the grade) focused on learners’ perception skills (identification and discrimination) of phonemic and prosodic audio stimuli pronounced by male and female RP voices, as well as on their ability to annotate them into a phonetic transcription. Both the Pre- and Post-EPSSML groups in their corresponding academic years were given the same amount of time to finish their exams: two and a half hours for the first two tests, which took place in a classroom on the exam day, and half an hour for the lab test, which was held in the language lab on a different day.

Taken together, the only difference between the two datasets was the type of instruction received. Pre-EPSSML students followed a traditional face-to-face TCI program, in which learners were passive recipients and teachers promoted the learning of knowledge in a step-by-step process based on classic English phonetics and phonology materials that were not specifically devised for SSLE (e.g., Cruttenden, 2014; Gimson, 1989; Roach, 2009). Post-EPSSML learners, on the other hand, received blended instruction, combining traditional face-to-face, in-class TCI instruction with EPSSML-mediated phonetic training specially designed for SSLE to foster their active participation and the collaborative use of materials during the teaching-learning process. Online technology was utilized to deliver a substantial portion (50%) of the content, and interaction with instructors and other students was done through online discussions and three different types of face-to-face instruction in expository, seminar, and lab sessions. Students were given specific tasks concerning EPSSML audio-visual and written materials and resources on the seven units of the course every week to work on at home, and they posted questions and answers to an online discussion board and through the course Moodle platform that were open only to class to obtain feedback from their peers and instructors.

In addition, we analyzed post-EPSSML students’ level of agreement to a 16-item questionnaire displayed in Table 4 (Appendix C) using a 5-point Likert scale with the following labels: Strongly disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5). The questionnaire was divided into two groups of questions (Q). The first group (Q1 to Q10) included questions about students’ satisfaction with the use of the EPSSML platform itself, whereas the second (Q11 to Q16) focused on the course web-mediated blended methodology.

Lastly, to show the reliability of our findings, descriptive statistics are presented as absolute and relative frequencies for categorical variables, and as median and first and third quartiles for ordinal variables (Appendix D). Differences between percentages of responses in students’ questionnaires are evaluated through the χ2 test or Fisher exact test (if expected cell frequency is less than 5), followed by a post-hoc test for evaluating differences between pairs of categories (Agresti, 2007). In addition to these measurements, the Mann-Whitney U test (non-parametric equivalent of t-test) for ordinal and discrete variables is used to determine differences across female and male respondents. In the case of course results, Multinomial Logistic regression is applied since the outcome variable is multinomial, rather than ordinal, due to the presence of the category NO SHOW. It estimates the probability of being in a given category (PASS) related to the other categories (NO SHOW, FAIL). Student group and sex are included in the model as covariates because results confirmed that there is no interaction between them. All the analyses were carried out with R free software (R Core Team, 2020) alongside the packages ggplot2 (Wickham, 2016) and effects (Fox & Andersen, 2006) for making the plots, the package net (Venables & Ripley, 2002) for multinomial analysis, and the package psych (Revelle, 2021) for internal consistency analysis.
Results

RQ1: Is the CAPT01 website EPSSML an effective resource to teach English phonetics and phonology (to Spanish EFL) in a blended environment?

Figure 2 shows relative frequencies for test scores across the Pre- and Post-EPSSML sets. The first thing to be noted is that the percentage of NO SHOWs dropped by half from 50.0% of learners that did not use the website to 20.3% of students that did use the e-platform during their instruction. Moreover, the increase in the number of students (re)sitting for their final assessment is replicated in the number of learners passing the course, which increased from 37.7% before using EPSSML to 53.3% when the e-platform was used.

Coefficients estimated by the multinomial model taking PASS as outcome variable are presented in Table 5, showing estimates of slope parameters and standard errors, relative risk ratios and their 95% confidence intervals, as well as p-values. The figures represent Relative Risk Ratios (RRR) in terms of reduction ((1 - RRR) x 100 [for RRR < 1]) or increase of risk ((RRR - 1) x 100 [for RRR > 1]) in percentage of being in the category PASS. The results confirm that there are significant differences related to the use of EPSSML for the score NO SHOW: students using the website have an increased RRR of being in the category PASS by a factor of 2.349, registering an increased RRR PASS rate of 135%. In other words, after using EPSSML, there are more students taking the exam and passing it. This first finding demonstrates that students that received EPSSML-mediated instruction outperformed the Pre-EPSSML group in sitting for and passing the course (regardless of score achieved).

Figure 2

*Course Results Across Pre- and Post-EPSSML*
Table 5

Coefficients Estimated by Multinomial Model with PASS as the Outcome Category

<table>
<thead>
<tr>
<th>Contrasts</th>
<th>Estimate</th>
<th>SE</th>
<th>RRR</th>
<th>RRR.CI_low.</th>
<th>RRR.CI_up.</th>
<th>p.value</th>
<th>Signif</th>
</tr>
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<tbody>
<tr>
<td>FAIL vs. PASS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.784</td>
<td>0.154</td>
<td>0.457</td>
<td>0.337</td>
<td>0.618</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Before EPSSML vs.</td>
<td>-0.410</td>
<td>0.261</td>
<td>0.664</td>
<td>0.398</td>
<td>1.107</td>
<td>0.116</td>
<td>ns</td>
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<tr>
<td>After EPSSML</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sex: Male vs. Female</td>
<td>0.497</td>
<td>0.318</td>
<td>1.644</td>
<td>0.882</td>
<td>3.066</td>
<td>0.118</td>
<td>ns</td>
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<tr>
<td>NO SHOW vs. PASS</td>
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</tr>
<tr>
<td>(Intercept)</td>
<td>-1.205</td>
<td>0.173</td>
<td>0.300</td>
<td>0.214</td>
<td>0.421</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>Before EPSSML vs.</td>
<td>1.279</td>
<td>0.217</td>
<td>3.594</td>
<td>2.349</td>
<td>5.500</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>After EPSSML</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex: Male vs. Female</td>
<td>1.094</td>
<td>0.269</td>
<td>2.986</td>
<td>1.761</td>
<td>5.063</td>
<td>0.000</td>
<td>***</td>
</tr>
</tbody>
</table>

Figure 3

Course Results Over a Four-year Period (%)
Zooming in on the grade scale, the two study groups registered similar percentages for GOOD (7–8/10 points; 11%), but the numbers for MERIT (9–10/10 points; 4% vs. 3%), PASS (5–6/10 points; 38% vs. 23%), and FAIL (less than 5 points; 22% vs. 10%) were higher in the Post-EPSSML sample. Viewing these results along the 4-year study timeline, the line graph in Figure 3 above suggests that the 2017/2018 academic year, in which EPSSML-mediated blended phonetic instruction was introduced, constitutes a turning point as it marks a change of direction in these five grade values. The dramatic decrease of NO SHOWs (58.6% vs. 36.2%) contrasts with the steady increase of the remaining values, whether they be passing grades, for example, PASS (21.6% vs. 36.2%), GOOD (7.2% vs. 12.3%), MERIT (2.7% vs. 2.9%), or not (FAILS 9.9% vs. 12.3%). Moreover, the decrease of NO SHOWs has a reversed proportional relation with the increase of PASS and FAIL rates, of which the former outnumbers the latter by as much as 16 percentage points.

**RQ2: What are the (Spanish EFL) students’ attitudes towards EPSSML-mediated, blended EFL phonetic instruction?**

Students’ responses to the 16-item questionnaire are graphically presented in Figure 4, while the corresponding numerical information is displayed in Tables 6, 7 and 8, showing absolute and relative frequencies of responses for aggregated measure with the $\chi^2$-squared statistic for comparing proportions and associated Chi-square $p$-values, median, and interquartile range of items with Mann-Whitney $p$-values, as well as the means and standard deviations of each item, respectively.

Figure 4

*Bar Plot Showing Percentages of Categories of Response for Each Item*

Results in Table 6 (Appendix D) suggest that most students have a good or very good opinion about EPSSML as the median values of responses are over 4 for all the items—except for item Q5—for the aggregated measure (resulting from aggregation of the items), with $p$-values of the 2-sample test for equality of proportions below 0.05 when comparing category 4 with the rest as displayed in Table 7. The fact that Q5 obtained a relatively low score indicates that students think that more time should be devoted to the
assimilation of the contents included in both EPSSML and the course. This was a predictable finding in view of the high ratio of FAILs attested in both the Pre- and Post-EPSSML groups in the Results (RQ1) section. Additionally, as can be seen in Table 8 (Appendix D), the average scores for the first group of questions (Q1 to Q10) concerning the satisfaction with the EPSSML website itself and the second group (Q11 to Q16) targeting the course methodology are 3.68 and 3.95, respectively. These two high scores allow us to confirm the high degree of student satisfaction with both the EPSSML tool and the course blended instruction. The values in Table 8 also reveal that, within the first set of questions focusing on EPSSML, Q3, Q4, and Q10 receive the highest average score, while Q5 and Q9 register the lowest scores. Turning to the inquiry of methodology, the questions that receive the highest degree of satisfaction are Q13, Q15, and Q16, and the lowest Q11 and Q14.

**Table 7**
*Descriptive Table of Absolute and Relative Frequencies of Responses for Aggregated Measure (Total Values as Well as Values Aggregated by Sex, with χ-Squared Statistic for Comparing Proportions and Associated p-Value)*

<table>
<thead>
<tr>
<th>Reference Category:</th>
<th>[ALL]</th>
<th>FEMALE</th>
<th>MALE</th>
<th>χ-squared</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 1994</td>
<td>N = 1818</td>
<td>N = 176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>89 (4.46%)</td>
<td>86 (4.73%)</td>
<td>3 (1.70%)</td>
<td>636.37</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>2</td>
<td>139 (6.97%)</td>
<td>126 (6.93%)</td>
<td>13 (7.39%)</td>
<td>518.75</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>3</td>
<td>386 (19.4%)</td>
<td>363 (20.0%)</td>
<td>23 (13.1%)</td>
<td>150.27</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>4</td>
<td>735 (36.9%)</td>
<td>654 (36.0%)</td>
<td>81 (46.0%)</td>
<td>8.77</td>
<td>p &lt; 0.003</td>
</tr>
<tr>
<td>5</td>
<td>645 (32.3%)</td>
<td>589 (32.4%)</td>
<td>56 (31.8%)</td>
<td>8.77</td>
<td>p &lt; 0.003</td>
</tr>
</tbody>
</table>

Q3  Do you consider that the objectives of this e-learning platform are coherent with the training activities proposed?

Q4  Do you reckon that this platform is an effective instrument for teaching and training students in English phonetics & pronunciation learning?

Q5  Do you feel that the contents of the platform can be assimilated in one semester?

Q9  Have there been any technical difficulties concerned with EPSSML?

Q10 Which is your degree of satisfaction with EPSSML?

Q11 Do you feel that course sessions are appropriately planned, ensuring appropriate activity design and implementation?

Q13 Have the EPSSML materials been useful for the course sessions?

Q14 Do you perceive a good coworking environment in the course?

Q15 Have office hours favored the adequate acquisition of course contents, and have they helped clarify any doubts?

Q16 Have you received enough feed-back and support from your course teachers?
To determine the reliability of our results, and to confirm that the aggregation of items could be carried out, first, we analyzed the scale dimension through parallel analysis, a technique that compares the eigenvalues of the observed data matrix with a simulated data matrix of the same number of observations and variables as the original, using principal axis factor analysis. Parallel analysis determines only one factor to be extracted, as can be seen in the screen plot in Figure 5. The appropriate number of factors to be retained is marked by a hard break in the plot, while the estimation values of the differences at the aggregated level are displayed in Table 6.

**Figure 5**

*Explanatory Factor Analysis of Questionnaire Results*

After conducting the exploratory factor analysis, the next step was to determine the internal reliability of the questionnaire results through the Cronbach’s alpha ($\alpha$) parameter using the equation (Eq. 1) below. It is generally assumed that a value of alpha of <.6 is unacceptable, < .65 is undesirable, < .7 is minimally acceptable, < .8 is respectable, < .9 is very good, and >=.9 highest reliability. In this case, Cronbach’s alpha has a value of 0.9874, which indicates a very high internal consistency, thereby confirming the validity of our questionnaire results.

$$\text{Eq. (1) } \alpha = \frac{k}{(k-1)} \cdot \left[1 - \frac{\sum_{i=1}^{n} \sigma_i}{\sigma_T}\right]$$

**RQ3: Are there any gender-based differences regarding RQ1 and RQ2?**

Lastly, examining the findings according to gender, Figure 6 and Table 5 below show estimated probabilities for each category of the outcome (test scores) for the gender-related variable. The results confirm that women have an increased RRR of being in category PASS (related to NO SHOW) by a factor of 1.761, that is, an increased RRR PASS of 76.1%. Put differently, female students, who were the group with higher percentages of NO SHOW before EPSSML, have a significant increase of the RRR PASS ratio compared to their male peers. Furthermore, it can also be observed that female students outperformed male students in the course PASS rate, both in the Pre- and Post-EPSSML samples.
Additionally, Figure 7 alongside Tables 6 (Appendix D) and 7 (above) provide evidence of SSLE’s positive perceptions towards both EPSSML and the course’s blended instruction. They constitute a steady pattern reflecting the majority view irrespective of gender variation as there are no statistically significant differences across male and female EFL students in any of the 16 items included in the questionnaire.
Discussion

Given the critical need to improve SSLE’s (and more generally EFL learners’) knowledge and performance in phonetics-related content and skills, the findings from this study are encouraging. Firstly, the data concerning RQ1 indicate the effectiveness of EPSSML-mediated, blended phonetic instruction in the context of a university EFL degree in Spain. Students were reported to increase their academic achievements by fostering learning motivation and course participation, which empowered them with the necessary capabilities and attitudes to decide not to drop the class. The NO SHOW rate decreased almost by half and as a result the general PASS rate (and specifically the MERIT and PASS scores) increased significantly as compared with the much higher abandonment and lower results registered in the Pre-EPSSML group trained in the same amount of time with a TCI methodology alone. This study therefore aligns with previous meta-analyses concluding that blended instruction is on average more effective and can decrease the limitations of traditional TCI (Means et al., 2009; Vernadakis et al., 2011). It showed positive changes in the levels of formation of phonetic competence of SSLE through EPSSML-mediated blended instruction, creating favorable conditions for professional training and collaborative work while acquiring CAPT-related digital skills.

Similarly, our results confirm the findings of the bulk of previous empirical studies already summarized, proving the effectiveness of CAPT tools for different kinds of phonetic training. They also corroborate those of preceding investigations, revealing that explicit phonetic instruction and perception training paradigms—in our case using EPSSML-mediated blended methodologies—raise EFL learners’ phonetic/phonological awareness and perception skills (Gómez Lacabex & Gallardo del Puerto, 2020; Ramírez Verdugo, 2016; Saito, 2011, 2013), which, according to prior experiments, can also be transferred to students’ production skills (Carlet & Cebrian, 2019; Thomson, 2011). Furthermore, the better course results of the Post-EPSSML group support the effectiveness of contrastive meta-phonetic input in teaching EFL phonetics (focusing on potential interference phenomena), as opposed to the non-contrastive methodology applied to the Pre-EPSSML group, which confirms the assumptions of the PAM and SLM paradigms already mentioned (Developing EPSSML section), as well as the conclusions of previous investigations on the positive effects of explicit contrastive teaching methods (Derwing & Munro, 2005; Kissling, 2013; Kralova et al., 2020).

On the other hand, it has been shown that web-mediated phonetic instruction can be successfully applied in a formal educational setting, which seems to compromise recent meta-analysis claiming that mobile learning is more effective in informal than in formal education (Sung et al., 2016). While other investigations have shown the efficiency of MALL tools in informal instructional contexts, it can also be affirmed that EPSSML may be an effective MALL resource in formal educational contexts as the platform can be used on both computers and handheld devices (smartphones, tablets, and the like). Hence, it follows that CALL/MALL developments may be successfully employed in both kinds of instruction provided they are adequately designed for the purpose intended. More generally, it could be concluded that blended methodologies through mobile technology are key to bridging the gap between formal and informal learning as they allow synergies between the specific affordances of both.

Additionally, our results refute those of earlier studies previously mentioned questioning the efficacy of online and blended courses, compared to traditional TCI. What the findings seem to suggest is that successful learning depends as much on the type of instruction received as it does on the solvency of the specific tools utilized and on the support available to learners and teachers. Educational technology is only as good as the pedagogy behind it, which highlights the need for collaboration between educational technologists, phonetics experts, and (EFL/EIL/ELF) teachers to ensure that the designs and functionalities of CAPT tools reflect learners’ needs and optimize pedagogical practices.
This leads us to RQ2. Our empirical evidence suggests that the majority of Post-EPSSML participants surveyed (116 out of 127, 91.3%), as digital natives, are satisfied with web-mediated blended EFL phonetic instruction. These results must be interpreted with some reservation as it is possible that only the most motivated students volunteered to answer the questionnaire. However, given the limited amount of class time available for the module (one semester in our case), the increase in technologies that enable ubiquitous, out-of-class learning are to be welcomed. Through EPSSML, English phonetics and phonology educational materials become available for students in mobile form (i.e., over 200 hundred downloadable audio-visual and written resources with their keys alongside a selection of CAPT tools and glossaries) to drill online English sounds and prosody in addition to other course contents. Such materials give opportunity for learning autonomy, adaptation to learners’ needs and pace, practically unlimited input, and intensive practice in anxiety/stress-free learning in order to nullify the effects of negative affective factors that have been related to lower levels of linguistic performance (Teimouri et al., 2019).

Our findings therefore contradict previous claims that students prefer paper materials and traditional teacher-centred methodologies for their lack of digital skills. Moreover, in the opinion of most of our informants, the objectives established in the development of the platform are consistent with those of the course and the activities proposed, and ultimately, they perceive the e-platform as an effective tool in learning English phonetics and phonology. This conclusion becomes even more important in light of previous surveys according to which the activities most frequently used by EFL/EIL/ELF phonetics teachers often conflict or do not necessarily coincide with those rated as the most effective (Murphy, 2011). The disconnection between what phonetics teachers generally do in class and which activities really work according to users’ perceptions is worthy of attention.

Moving on to the gender implications of our study in RQ3: Are there any gender-based differences regarding RQ1 and RQ2? We have seen that female students outperformed males both in the Pre- and Post-EPSSML groups and that this effect was even stronger after EPSSML-mediated instruction. Although the small sample size of the study might undermine the generalizability of findings, they are in keeping with those of other investigations in second language learning (Aslan, 2009; Lin, 2003). Some of them proclaim that, on the basis of psychometric testing, observation, and imaging techniques, females process language activities more easily, earlier, and faster than males, while males excel more at spatial-mechanical and gross motor skill tasks (Magon, 2009). Furthermore, contrary to what has been concluded in other research previously mentioned, the general picture that emerges from our results seems to suggest that, at least in the Spanish context of this study, there is no gender breach regarding the use of technology-mediated, blended phonetic instruction, nor in relation to the students’ positive attitudes towards it as there were no statistically significant differences across genders in this respect. Our data consequently not only corroborate the inclusiveness potential of EPSSML and blended teaching methodologies, but also can be seen as positive indicators of a decrease in the gender bias.

Promising though these findings may seem, our tests also reveal that a considerable number of students continue to fail the course. This fact supports the conclusions of those investigations already cited arguing that EFL/EIL/ELF learners find English phonetic contents to be difficult or challenging. To minimize these negative perceptions, further research alongside innovation should be promoted in this important component of EFL/EIL/ELF teaching and learning, ensuring the provision of adequate educational materials and policies. The EFL/EIL/ELF curriculum and syllabus should be reconsidered in such a manner that more time is allotted to such core subjects as phonetics and pronunciation in lower and higher education. Moreover, the high failing rate appears to suggest that, despite the use of CAPT tools for EFL/ELF/EIL phonetic training, just one semester of instruction in specialized phonetics courses—as in the case of this experiment—is not enough. We believe that the implementation of additional small group training courses and the gradual development of phonetic instruction throughout the different stages of the educational process are essential to the students’ success. To this end, more resources should be allocated including the training and hiring of qualified members of staff. Instructors should be able to receive professional development in phonetic and pronunciation teaching (on a voluntary but adequately funded and equipped basis), looking for ways to upskill themselves with a range of existing practices and available
However, it is not possible to ascribe the fail rate to time alone. Another dimension to look at is the students’ exact engagement with the tool and the course. Given the negative perceptions of the subject and the big size of the groups, it would be reasonable to think that the high ratio of NO SHOWs and FAILs may be due to the fact that many students may be intimidated by the course and postpone sitting the exam as much as they can, and some try their luck and just take the exams without studying too much or without attending classes regularly and therefore without completing the assignments required either. By the same token, it would be reasonable to think that students who practiced more often or for longer periods of time performed better and engaged with the subject more intensively than those who practiced or studied less. To put it simply, it would be expected that both the subject itself and EPSSML did not engage students equally. Nevertheless, it goes beyond the scope of this paper to examine these extremes or all the relevant variables involved in their analysis (e.g., the degree to which each student used the tool or the Moodle course materials as instructed, how often and for how long, among others), which would require a Learning Analytics approach and would deserve a study on its own. In addition to space limitations, another constraint that prevents us from providing a substantive account of this dimension in this study is the fact that the Google Analytics of EPSSML was installed one year after the period covered in the experiment, although its reports since then are encouraging. As can be seen in Figure 8, from November 2019 to January 2023, the platform registered 7,613 users across virtually every country in the world, even if the tool is primarily aimed at speakers of Spanish. The top 10 countries with the highest number of visits are: Spain, Argentina, USA, Colombia, Mexico, Vietnam, Russia, Thailand, Algeria, and Chile.

**Figure 8**

*Google Analytics Report for EPSSML*
Another pedagogical implication of the students’ responses is that the topics discussed in class may need revising in order to lessen the workload during the semester. The presentation of materials could be tailored somewhat differently so as to ease and motivate learners even more. Possible steps in this direction could be extracurricular activities (e.g., podcasts, jokes, songs, contests on phonetic and phonological contents, and ortho-phonetic skills such as perception, diction, transcription, and spelling) or the design of serious games (i.e., games with an educational purpose) (Caballero-Hernández et al., 2017; Moizer et al., 2019), targeting in this case English phonetics. The affordances of online games and simulations for both CAPT and CALL are increasingly being recognized as they have proved useful motivational and engaging instructional tools that can create effective social practices for users to participate in communities sharing learning interests (Gudwin-Jones, 2014; Golonka et al., 2014). Other key elements of game-based methodologies are that they can provide students with fun and challenging scenarios in which to practice task-based language and phonetic learning (Pennington & Rogerson-Revell, 2019). An example of such initiatives is our development of a serious game addressed to SSLE using pilgrim avatars on the Way of St. James with the purpose of providing extensive exposure to and practice on English phonetics contents and skills (perception, production, and transcription) in an immersive experience that reduces anxiety, but maintains the elements of competition, problem solving, and reward for successful task completion (Gómez González et al., 2023; Lago Ferreiro et al., 2022). All these features can motivate learners to engage not only with the learning content, but also with peers from different backgrounds, which can be of benefit for teaching and learning phonetics.

Lastly, it should be observed that the type of content covered affects the amount and type of online instructional technology. The course under inspection combines declarative phonetics and phonology knowledge with skill-based (perception, production, and transcription) content. While the former does not necessarily need repeated practice and may be better suited for discussions in face-to-face sessions, skill-based content needs to be imparted in phases with obvious opportunities for feedback and correction, whether automated or not, which must be correct and reliable (Walker, 2014). External feedback is thus essential for phonetic instruction to highlight those aspects that should be improved (Mitterer et al., 2020), especially considering that many L2 speakers are reported to be unable to identify their own phonetic skill-based deficits (Derwing & Rossiter, 2002), or to be incapable of “hearing” the target pronunciation even when it is modeled by their teachers, instead continuing with their original, incorrect pronunciation (Reed & Michaud, 2011). Although our informants assessed positively the feedback provided online as well as during face-to-face in-class and office hour instruction, it is our future challenge to improve the tool's interface and interactivity. Based on the results of the questionnaire, navigability should be even more intuitive as respondents reported to have experienced technical issues. Besides, the current Google Analytics module could be improved by leveraging more modern data-visualization technologies. Additional improvements would also have to involve the incorporation of an ASR module as well as a Student’s module, both assisted by artificial intelligence (AI) systems. The former would help students enhance their speaking skills, which would require resolving the challenges of ASR with an efficient algorithm for speech recognition. The Student’s module, on the other hand, would include information about personal and recurrent phonetic mistakes during instruction. Simultaneously, it would provide self-tests and progress reviews to reinforce positive attitudes and motivation, by giving rewards when activities are successfully completed and offering minimal feedback as a default, with much richer feedback available on request (depending on individual needs) to explain why users fail to fulfill or accomplish the targets (Engwall & Bälter, 2007; Moyer, 2007). This is in line with the last decade’s shift in the educational paradigm from a mere cognitive approach to a more holistic and integral view of teachers and students in SLA integrating positive and negative emotions in the learning and teaching processes (Dewaele & Li, 2018).
Conclusions

The current investigation aimed at assessing the pedagogical benefits of blended teaching as substantiated in EPSSML, an e-platform for web-mediated EFL phonetic instruction specially devised for speakers of Spanish, while simultaneously unveiling the learners’ attitudes towards that type of instruction as well as any gender inequalities that may exist. The study provided compelling evidence of the effectiveness, positive perceptions, and inclusiveness potential of EPSSML. More generally, it advocated for computer/web-assisted EFL phonetic training within the EFL curriculum, confirming the benefits of a paradigm shift toward blended learning language methodologies in higher education that fosters digital literacies, autonomous learning, gender inclusion, and course participation. Finally, the tools surveyed and the insights offered on CAPT devices and methodologies, as well as on how they can be situated within the theoretical principles from Clark (2009) and Mayer (2008; 2009), can provide significant guidance for learners, instructors, and instructional designers in this context.

The study is limited in that it has not examined the effects of technology-supported feedback on learners’ pronunciation performance, mainly due to the constraints imposed by the course assessment policy and the curriculum. Nor has it broken down the individual results of the students with respect to each of the three components measured in the course (e.g., declarative knowledge of English phonetics and phonology alongside transcription and perception skills) or their degree of involvement in the course through Learning Analytics techniques. Follow-up studies with data analytics and a combination of cognitive and more nuanced competence-based results, including the possibility of conducting “natural experiments” (Dunning, 2012) to explain individual differences and other unique properties associated with the data and collection procedure, are warranted to further assess students’ performance and the effectiveness of the tool. These types of studies are also essential in tracing whether and how teachers and learners use or continue to use EPSSML both in Spain and in other countries, which would shed more light on the usefulness of the platform and on the benefits of web-mediated EFL phonetic instruction.

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Notes

1 Blended teaching and learning methodologies use a blend of a range of delivery media, face-to-face (synchronous) class-based methods, distance-learning (both synchronous and asynchronous) methods, and self-directed learning. They usually involve mixed approaches advocating a compromise between face-to-face delivery and computer-based distance learning, giving students greater autonomy in developing self-management skills in accordance with their learning styles and proficiency levels (Clark & Mayer, 2011; Jordan et al., 2008).

2 Although production/pronunciation skills are also practiced in laboratory sessions (Instrumentation section), they are assessed in other courses of the degree due to time constraints and the demands of the curriculum.
3 The three different sessions were instructed in three different settings during one semester: 24 expositive lectures in bigger joint groups with an average of 50 attendees, 16 interactive sessions in smaller seminars with 25 students, and 16 laboratory sessions with an average of 10 learners, each type lasting about 50 minutes. Additionally, students received three hours of personal or group tutorials to guide the 99 hours of independent work per semester required in this course.

4 Multinomial Logistic regression (Venables & Ripley, 2002) is an extension of binary logistic regression that allows for more than two levels of the outcome variable. Results from models are presented as Relative Risk Ratios (RRR) with a 95% confidence interval, as well as in graph format showing predicted probabilities for each category of the outcome. An RRR < 1 reflects that the risk of the outcome to fall in category r (related to reference category) is reduced when covariate value increases (maintaining the other covariate in its reference category). On the contrary, an RRR > 1 represents an increased risk in category r.

5 The blue line and the dotted red line in Figure 5 represent actual data and simulated data, respectively.

6 As a clarification, \( k \) corresponds to number of questions (16), \( \sigma_i \) represents the variance of each question, \( \Sigma_T \) is the total variance (224.94), and \( \Sigma_{i=1}^{n} \sigma_i \) equals 16.7.


Appendix A. OVERVIEW OF CAPT TOOLS

Table 1
Overview of CAPT Tools

<table>
<thead>
<tr>
<th>CAPT01 E-books, Online Dictionaries, Websites, Blogs, and Tutorials</th>
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<table>
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<td>Peter Roach: <a href="https://www.peterroach.net/">https://www.peterroach.net/</a></td>
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<td>Jane Setter: <a href="https://www.reading.ac.uk/elal/staff/professor-jane-Setter">https://www.reading.ac.uk/elal/staff/professor-jane-Setter</a></td>
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LearnEnglish Teens-British Council: https://learnenglishteens.britishcouncil.org/
Liveworksheets: https://es.liveworksheets.com/worksheets/en
AngloTIC: https://www.uv.es/anglotic/phonology/index.html
Antimoon: https://www.antimoon.com/

BBC pronunciation:
https://www.bbc.co.uk/learningenglish/english/features/pronunciation;
https://www.bbc.co.uk/learningenglish/english/features/pronunciation/vlessconst6;
http://downloads.bbc.co.uk/worldservice/learningenglish/pronunciation/pdf/quiz/pronunciation_quiz_1.pdf

British Council Phonetics: https://www.teachingenglish.org.uk/article/phonetics

British Council Teaching English pronunciation online:
http://www/englishpronunciationmadrid.com/vowels/vowels/vowel-shortening

David Brett: http://davidbrett.uniss.it/

Exercises of UCL: https://www.phon.ucl.ac.uk/resource/tutorials.html

English Accent Coach: https://www.englishaccentcoach.com/

English phonetics at UAB:

English Pronunciation for Spanish (and other non-native) speakers:
http://www/englishpronunciationmadrid.com/

Paul Seligson and Carmen Dolz:

ESL lounge student: https://www.esl-lounge.com/student/pronunciation.php

ESL Pronunciation Games for Teaching Kids, Teens, and Adults: https://bridge.edu/tefl/blog/esl-pronunciation-games/

Interactive Sagittal Section: https://incl.pl/sammy/

Multimedia English: https://multimedia-english.com/phonetics

Phonetics resources: https://users.castle.unc.edu/~jlsmith/phonetics-resources.html

Seeing speech: https://www.seeingspeech.ac.uk/ipa-charts/

SIL software for the Analysis and Transcription of Sound: https://www.sil.org/linguistics/linguistics-software

Sounds of Speech (University of Iowa): https://soundsofspeech.uiowa.edu/home

TeacherApp English Resources: https://resources.teacherappenglish.com/phonetics/


The University of Iowa Speaking Center: https://speakingcenter.uiowa.edu/phonunciation-resources

**CAPT02 Software and Programs**

**Phonics and Transcription**

IPA palette para MAC: https://www.blugs.com/IPAPalette/

Mansion Inglés (only pronunciation): http://www.mansioningles.com/recursos17.htm

CUBE Dictionary: http://cubedictionary.org/

Interactive Phonetic Chart: https://www.englishclub.com/pronunciation/phonemic-chart-ia.htm

IPA Online keyboard: https://ipa.typeit.org/


Lingorado: https://lingorado.com

Phonetizer: https://www.phonetizer.com/ui

PhoTransEdit: http://www.photransedit.com/

The Phonemic Chart Keyboard: http://www.phonemicchart.com/

toPhonetics: https://tophonetics.com/

Typeit: https://ipa.typeit.org/

**SRT, TTS, ASR, Audio Editing Software**

Audacity: https://www.audacityteam.org/


Google Cloud Speech to Text: https://cloud.google.com/speech-to-text?hl=es

Just Press Record: https://sourceforge.net/software/product/Just-Press-Record/

Pearson Test of English (PTE) Academic: https://pearsonpte.com/

Pearson’s Versant: https://www.pearson.com/english/versant.html

Praat: https://www.fon.hum.uva.nl/praat/
SFS/RTSPECT: https://www.phon.ucl.ac.uk/resource/sfs/rtspect/
SFS/WASP: https://www.phon.ucl.ac.uk/resource/sfs/wasp/
Swype: https://swype.softonic.com/android
Tell Me More: https://www.rosettastone.com/
Twilio Voice: https://www.twilio.com/es-mx/voice

CAPT03 Apps

Blue Canoe (course): https://bluecanoelearning.com/
Elsa Speak: https://elsaspeak.com/en/
Clear Speech: https://www.pinterest.es/pin/260786634642652558/
Cool Speech: https://www.speechinaction.org/cool-speech-app-banner/
Lyrics training:
Pronunroid – IPA pronunciation:
Say it English Pronunciation, speak English
Sounds. The pronunciation app:
http://www.macmillanstraightforward.com/resources/sounds-pronunciation-app/

CAPT04 Other

Audios

Apple music with lyrics: https://support.apple.com/en-us/HT204459
Eat Sleep Dream English: https://www.youtube.com/channel/UCu4AP8qmYnXNUipUeyPQKig
Google translator (audio):
https://support.google.com/translate/answer/6142468?hl=en&co=GENIE.Platform%3DDesktop
IDEA: https://www.dialectsarchive.com/

mmmEnglish: https://www.youtube.com/c/mmmEnglish_Emma

Natural Readers: https://www.naturalreaders.com/

Rachel’s English: https://rachelsenglish.com/

**Online Channels**

Teach yourself English Phonetics: https://canal.uned.es/series/5a7ae069b1111f72578b456f

**Creation of Materials**

Kahoot: https://kahoot.it/

Socrative: https://www.socrative.com/

Quizzit: https://quizizz.com/admin/quiz/5fade969f8ab8a001bda5395/quizzit

Voki: https://l-www.voki.com/

WinPitch: https://www.winpitch.com/
Appendix B. Sample Test

SAMPLE TESTS

English Phonetics & Phonology: Expositive sessions test

All expositive sessions exams conformed to this format.

SECTION A: Provide a full description of /s/ and /z/ (4 POINTS)

SECTION B: Annotate allophonic variation in the following words (1 POINT):

A. big geese
B. Take my excuses
C. twice scarce

SECTION C: MULTIPLE CHOICE TEST: Tick the right answer, only one is correct

1. In RP the unstressed vowel of into …:
   A. is qualitatively very similar to CV 8.
   B. coincides with the stressed vowel of woman.
   C. is open, back, slightly-rounded.
   D. is close to CV 14.

2. Amplitude is:
   A. an auditory category directly related to formant structure.
   B. an acoustic feature directly related to tone.
   C. an acoustic category directly related to intensity.
   D. an auditory feature directly related to duration.

3. So-called pre-fortis clipping affects the stressed vowel of:
   A. flees.
   B. advertised.
   C. dies.
   D. ceased.

4. In RP the stressed vowel of branch:
   A. has the same quality as CV. no. 4.
   B. is front, unrounded, between half-open and half-close.
   C. coincides with the stressed vowel of after.
   D. undergoes pre-fortis clipping.
5. **Spot the example of regressive assimilation involving place.**
   A. [ˈhæp̩m̩d].
   B. [kʌp m ˈsɔ:sə].
   C. [əm məin].
   D. [ðiʃɒt].

6. **Choose the correct statement:**
   A. Voiced plosives have a positive V.O.T.
   B. In fricative articulation, the hole through which the air escapes may be narrow and deep (groove) or wide and shallow (slit).
   C. The allophones of a phoneme are in contrastive distribution.
   D. In RP the rhyme of the citation form triumphs is /mfs/.

7. **Tick the odd one out:**
   A. wear/were.
   B. pair/pear.
   C. lice/lies.
   D. farther/father.

8. **Allophones are said to:**
   A. result from a fusion of two segments.
   B. be in contrastive distribution.
   C. entail the loss of a phonological opposition.
   D. be in complementary distribution.

9. **Tick the incorrect annotation of lexical stress:**
   A. /ˈextremist/.
   B. /ˌdisaˈppointment/.
   C. /ˈrefjuːs/.
   D. /frɪˈkwent/.

10. **Which phonation mode is illustrated below?:**
    A. Voice.
    B. Unvoiced.
    C. Glottal stop.
    D. Creak.
English Phonetics & Phonology: Seminar sessions test

All seminar transcription practice exams conformed to this format.

1. Transcribe the following words. Mark the stresses where necessary (3 points):

   cruise
   mouse
   exact
   analyse
   occasion
   individual

2. Homophones. Give two spellings for the following transcriptions (1 point):

   /aɪl/
   /reɪz/

3. Transcribe the following words in the appropriate column corresponding to the stressed vowel. Transcribe also the odd one out. (2.25 points).

   cauliflower clerk began mayor muscle yacht tongue dancer ankle

   /æ/ /ɑː/ /ʌ/ /ɒ/ Odd one out
4. **Transcribe the following text.** Mark primary stresses on all lexical words, use weak forms, and show any instances of linking /r/ and syllabicity. Mark pauses with one or two vertical bars. (4.75 points)

*But my all-time favourite is the lady I once saw driving down the motorway at a steady eighty miles per hour while plaiting her hair. The funny this is that, when she was pulled up by the police, she was driving with one hand on the steering wheel and the other holding an eyeliner. Mind you, she was fined for speeding, not for multitasking. Does that prove that the police cannot multitask themselves? Perhaps the fact the two officers were men was not irrelevant either.*

**English Phonetics & Phonology: Lab sessions test key**

The key is provided as students had to listen to audio stimuli in the phonetic lab that they could listen to four times. The test design observed the following guidelines:

1. Four minimal pairs testing vowel/consonant sounds: three of which should display monosyllabic CVC patterns.
2. Disyllabic words with different syllabic patterns focusing on challenging issues (vowel contrasts, consonant clusters, fricatives, and the like)
3. Polysyllabic words practicing the same phenomena as above as well as word stress placement rules.
4. Three sentences with an average of ten words to practice the previous issues alongside sentence stress and weak vs. strong forms.

1. **Transcribe the following minimal pairs and provide their spellings:**
   a. | kʌt | kæt | <cut, cat>
   b. | pɪn | bɪn | <pin, bin>
   c. | kʌp | kæp | <cup, cap>
   d. | ˈliːdʒən | ˈliːʒn̩ | <legion, lesion>

2. **Transcribe the following disyllabic words:**
   a. | ˈmeʒə | measure
   b. | ˈlændən | London
   c. | rɪˈzjuːm | resume
   d. | əˈbɜːmɪŋ | object (verb)

3. **Transcribe the following polysyllabic words:**
   a. | ,dʒæpəˈniːz | Japanese
   b. | ,rɛzəˈrekt | resurrect
   c. | səˈrendə | surrender
   d. | ˈbɜːmənʃm | Birmingham

4. **Transcribe the following sentences:**
a. I put the towel in the sink just a few minutes ago.
   | ˈai ˈpʊt ɒt ˈtəʊəl ɪn ɒt ˈsɪŋk ʤəʊst ə ˈfjuː ˈmɪnts əˈgəʊ |

b. I love her so much it really hurts sometimes.
   | ˈai lav hə ˈsəʊ ˈmʌtʃ ɪt ˈriəli ʰɪːts ˈsæntəmz |

c. There’s some trouble at the shop, according to him.
   | ðeəz səm ˈtrəbl ət ə ʃɒp | əˈkɔːdiŋ tu ɪm |
Appendix C. STUDENTS’ QUESTIONNAIRE

Table 4
Students’ Questionnaire on EPSSML

<table>
<thead>
<tr>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that your motivation towards English Phonetics has increased after using EPSSML?</td>
</tr>
<tr>
<td>Do you believe that the sequence of topic blocks included in EPSSML and their formative relevance are adequate?</td>
</tr>
<tr>
<td>Do you consider that the objectives of this e-learning platform are coherent with the training activities proposed?</td>
</tr>
<tr>
<td>Do you reckon that this platform is an effective instrument for teaching and training students in English phonetics &amp; pronunciation learning?</td>
</tr>
<tr>
<td>Do you feel that the contents of the platform can be assimilated in one semester?</td>
</tr>
<tr>
<td>Do you think that the difficulty level of the learning activities included in the platform is within the capabilities of English undergraduates?</td>
</tr>
<tr>
<td>Do you find that there is a coherent matching between learning activities and evaluation criteria and objectives?</td>
</tr>
<tr>
<td>Do you believe that the methodological guidance provided in the course English Phonetics and Phonology has been consistent with the experience of using EPSSML?</td>
</tr>
<tr>
<td>Have there been any technical difficulties concerned with EPSSML?</td>
</tr>
<tr>
<td>Which is your degree of satisfaction with EPSSML?</td>
</tr>
<tr>
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</tr>
<tr>
<td>Do you think that during the course sessions there has been: communication, assertiveness, neatness, conceptual clarity and correct exposition rhythm?</td>
</tr>
<tr>
<td>Have the EPSSML materials been useful for the course sessions?</td>
</tr>
<tr>
<td>Do you perceive a good coworking environment in the course?</td>
</tr>
<tr>
<td>Have office hours favoured the adequate acquisition of</td>
</tr>
</tbody>
</table>
course contents, and have they helped clarify any doubts?

Have you received enough feedback and support from your course teachers?
Appendix D. Tables and Descriptive Statistics

Table 6

Descriptive Table of Items by Sex, Showing Median and Interquartile Range, Odds Ratio (OR) and its 95% Confidence Interval and p-Value (p.ratio), as Well as p-Value from Mann-Whitney U Test (p.overall)

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<th>Item</th>
<th>[ALL]</th>
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<th>MALE</th>
<th>OR</th>
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### Table 8

EPSSML Questionnaire Results: Overview and Point Average

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<th># Questions</th>
<th>POINT AVERAGE</th>
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<td>Do you think that your motivation towards English Phonetics has increased after using EPSSML?</td>
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<td>Do you consider that the objectives of this e-learning platform are coherent with the training activities proposed?</td>
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<td>Do you reckon that this platform is an effective instrument for teaching and training students in English phonetics &amp; pronunciation learning?</td>
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<td>0.84</td>
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<td>Do you feel that the contents of the platform can be assimilated in one semester?</td>
<td>2.55</td>
<td>1.40</td>
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<tr>
<td>Do you think that the difficulty level of the learning activities included in the platform is within the capabilities of English undergraduates?</td>
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<td>0.91</td>
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<td>Do you find that there is a coherent matching between learning activities and evaluation criteria and objectives?</td>
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<td>Do you believe that the methodological guidance provided in the course English Phonetics and Phonology has been consistent with the experience of using EPSSML?</td>
<td>3.87</td>
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</table>
9. Have there been any technical difficulties concerned with EPSSML? 3.65 2.44

10. Which is your degree of satisfaction with EPSSML? 4.03 0.87

<table>
<thead>
<tr>
<th>Course Methodology: Web-mediated EPSSML-based Phonetic Training</th>
<th>SURVEY</th>
</tr>
</thead>
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<tr>
<td># Questions</td>
<td>POINT AVERAGE</td>
</tr>
<tr>
<td>11. Do you feel that course sessions are appropriately planned, ensuring appropriate activity design and implementation?</td>
<td>3.98</td>
</tr>
<tr>
<td>12. Do you think that during the course sessions there has been: communication, assertiveness, neatness, conceptual clarity and correct exposition rhythm?</td>
<td>4.01</td>
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<td>13. Have the EPSSML materials been useful for the course sessions?</td>
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</tr>
<tr>
<td>14. Do you perceive a good coworking environment in the course?</td>
<td>3.95</td>
</tr>
<tr>
<td>15. Have office hours favoured the adequate acquisition of course contents, and have they helped clarify any doubts?</td>
<td>4.20</td>
</tr>
<tr>
<td>16. Have you received enough feed-back and support from your course teachers?</td>
<td>4.11</td>
</tr>
</tbody>
</table>
About the Authors

María de los Ángeles Gómez González is Full Professor of English Language and Linguistics at the University of Santiago de Compostela (Spain) since 2006, as well as coordinator of the Scimitar research team. Her publications explore the grammar-discourse interface and ESL/EFL technology, including the book *English Pronunciation for Speakers of Spanish*, among others. María de los Ángeles Gómez González is the corresponding author.

**E-mail:** mdelosangeles.gomez@usc.es  
**ORCiD:** https://orcid.org/0000-0003-0575-8550

Alfonso Lago Ferreiro is an Associate Professor at the University of Vigo, Spain, since 1995. His main topics of interest are switching mode power supplies, control applied to power converters, and educational innovation. Dr. Lago is an IEEE Senior Member and Vice-Rector for Academic Staff, Teaching, and Study Programs of the University of Vigo.

**E-mail:** alago@uvigo.gal  
**ORCiD:** https://orcid.org/0000-0001-8697-4807