The CARE approach to incorporating undergraduate research in the phonetics/phonology classroom

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We introduce a pedagogical initiative, which we call collaborative active learning research-based education (CARE), for incorporating authentic research into the undergraduate classroom. CARE is founded on a broad base of pedagogical scholarship, which we summarize. We propose that there are numerous benefits to engaging students in research at the undergraduate level in the phonetics/phonology classroom, provided that the integration of research is done in a pedagogically sound manner. We describe an initiative carried out in the Spring 2019 semester, in which students in combined phonetics/phonology classes carried out acoustic and ultrasound studies of vowel-to-vowel coarticulation while simultaneously investigating vowel harmony from a phonological perspective. We propose that the CARE approach to developing a course-based undergraduate research experience is one way to integrate laboratory phonology into the undergraduate curriculum.*

Keywords: pedagogy, undergraduate research, laboratory phonology

1. INTRODUCTION. In this article we introduce a pedagogical initiative to incorporate research into the undergraduate phonetics and phonology classroom. We have dubbed this approach collaborative active learning research-based education (CARE) and, in doing so, encapsulate its major guiding principles, detailed in what follows. We describe the specific instantiation carried out in the Spring 2019 semester, which implemented the CARE approach in two Phonetics & Phonology courses, one taught at Carnegie Mellon University (CMU) in the United States by the first author, Christina Bjorndahl, and one taught at the Universidad de Navarra (UNAV) in Spain by the second author, Mark Gibson. The initiative comprised two separate but related themes. First, we designed a phonetic study and trained our undergraduate students to carry it out; second, we incorporated a phonological theme that was distinct from, but related to, the phonetic study. Specifically, throughout the course, the students carried out acoustic and ultrasound investigations of vowel-to-vowel coarticulation, while investigating the phonological theme of vowel harmony.

The pedagogical approach we describe stems from our experience as educators, from conversations with our colleagues, and from our reading of the pedagogical literature. In §2 we describe the implementation of the CARE approach in Spring 2019, and in the remaining sections we provide the background, context, and literature review that we feel justify the various components of the CARE framework. First and foremost, CARE is collaborative, in that it involves collaboration between faculty members, between students, and between students and faculty members. In engaging students as research peers, faculty put themselves into the position of not ‘having all the answers’. Because of this, and because CARE is research-based, active learning is the default mode of student engagement: students engage directly with the hypotheses, data, analysis, and interpretation of results. These components encode some of the core beliefs that we, as educators

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and researchers, take to be uncontroversial, but nonetheless consider worth stating explicitly from the start: that research is not about solitary scholars toiling away in isolation, but rather is generally collaborative; that students learn best when they are actively engaged with the material; and that students can be research peers. Together, these beliefs reflect an orientation toward pedagogy in which learning must be encapsulated in an experience, as per Kolb (1984), and learning experiences necessarily take place during, and as a result of, social interaction, where students not only learn from their own experiences but also learn from the successes and failures of their peers—and professors.

Part of our motivation for developing the CARE approach came from the desire to involve students in authentic laboratory phonology research. In particular, we wanted to find a way to do so that felt rewarding, for both ourselves and our students. Indeed, at least part of the motivation for developing CARE stemmed from dissatisfaction with final projects in previous iterations of these classes. Over the course of multiple semesters, we independently found that several issues arose which either compromised the quality of the final projects or made the experience more frustrating than it ought to have been, an observation that has also been shared with us anecdotally by several other instructors who use final or semester-long projects in their phonetics/phonology classes. First, students often struggle to come up with feasible topics on a reasonable timeline. Second, when students work independently, a loss of data is devastating to the project, because students typically collect data from only one or two speakers. Finally, projects that are very good are necessarily limited in both scope and potential impact because of the small number of speakers. These are issues that do not arise in CARE.

As might be surmised, the choice of the acronym is not accidental. As laboratory phonologists we feel fortunate to be part of a very friendly discipline, but academic life is often isolating, frustrating, and unyielding. Wanting to address this in even a small way, we believe that the enculturation of students into academic research ought to be done with care, in two senses of that phrase. That is, (i) it is important to be conscientious and deliberate about the enculturation process, and (ii) enculturation ought to be done with the students’ best interests in mind.

In addition to describing the implementation of the CARE approach in our own classes, a major goal of this article is to ground our pedagogical approach in existing research in the scholarship of teaching and learning (SoTL). As summarized in §2.5, there is an abundance of literature that shows the effectiveness of active learning, but much of this literature pertains to STEM fields and is framed in terms of students learning course content. In contrast, as we discuss in §4.1, although undergraduates are increasingly involved in research labs, the pedagogical value of such initiatives is not always clear, or at least is not always made explicit. Our goal in framing CARE as a pedagogical initiative is to ensure that integrating authentic research into the phonetics/phonology classroom capitalizes on what is known about how students learn, particularly with respect to active and collaborative learning. This is especially important given the recent surge of interest in both scholarly teaching and SoTL, which we take to signal that linguists are looking for innovative teaching methods.1

1 It is not entirely clear whether the interest in scholarly teaching is new or simply more visible. With the move to remote teaching caused by the COVID-19 pandemic, instructors are making connections online in ways that were not as visible previously, as in, for example, the Facebook group ‘Online linguistics teaching: Questions, tips & tricks’. However, we feel that this surge of interest is new as online teaching has forced instructors to reconsider their teaching methods. That said, we note that interest in scholarly teaching and SoTL had been steadily rising before the pandemic, evidenced by the LSA’s NSF-funded grant for 2019–2020 to form a Faculty Learning Community (of which the first author is a part) and the newly formed Special Interest Group on Scholarly Teaching (created from interest generated at the 2020 annual meeting of the LSA).
Bishop-Clark and Dietz-Uhler (2012) refer to SoTL as being in its ‘third wave’, specifically noting that most SoTL work is now founded on empirical data. To this end, this article presents some qualitative data on student experiences during our Spring 2019 initiative, as well as our assessment of the students’ contributions to the research study. Nevertheless, further research into the effectiveness of implementing the CARE framework is required, as detailed further in §5. By providing a model for integrating authentic research into the undergraduate curriculum, we hope other faculty at a variety of institutions will be motivated to incorporate CARE into their courses and to join us in assessing the effectiveness of the proposed methods.

To provide some disciplinary context, it is important to note that many linguistics departments, and phonetics laboratories in particular, involve undergraduate students in authentic research in ways that echo the principles of the CARE approach. Indeed, we have been inspired by the degree to which our colleagues at other institutions do so (surveyed in §4.2), as well as by the increasing sophistication of undergraduate research presented at both undergraduate and mainstream linguistics conferences. For example, Napoli et al. (2022, this issue) discuss an approach to structuring senior theses that we feel echoes many of the principles we outline here, particularly with respect to establishing a community of researchers. We feel that the CARE approach is complementary to existing models, and that it has a number of unique elements that make it a worthwhile contribution. For one, we implemented the research project into one of our existing undergraduate phonetics/phonology courses in order to eliminate barriers and increase the accessibility of research opportunities. Second, CARE is designed to be collaborative across institutions: our respective students presented their work to each other in an end-of-semester presentation, an experience that was roundly seen as a positive and exciting experience. CARE was conceived of and implemented before the COVID-19 pandemic, but we imagine more such teaching and research collaborations may open up with the more recent shifts to remote learning.

In terms of applicability, we believe our approach is suitable for students in many types of programs at various institutions, but our personal experience—and, indeed, our motivation for developing CARE in the first place—leads us to believe that it is of particular benefit in smaller programs and/or at institutions that do not have existing infrastructure for undergraduate research experiences. Although the departmental and institutional settings at CMU and UNA V are very different, in both cases the linguistics programs are not large enough to sustain separate streams of courses in phonetics and phonology and so offer combined phonetics/phonology courses. As a result, our conceptualization of CARE revolves around the pedagogical challenge of having students tackle a phonetic research project while learning how this research relates to the business of asking phonological questions, and in this way the approach is firmly grounded in our orientations as laboratory phonologists. To add to the pedagogical challenge, implementing CARE into already existing courses required us to be deliberate about how we cover what and when, so that we succeed in covering the appropriate amount of ‘core’ material.


2.1. Pedagogical context. Both authors teach combined Phonetics & Phonology courses, and in Spring 2019 we trained the students in our classes to carry out a research study, which tested four hypotheses related to vowel-to-vowel coarticulation in English (CMU) and in Spanish (UNA V). Students at CMU collected acoustic data, while students at UNA V collected ultrasound data. Students were responsible for all data collection and segmentation, and for carrying out preliminary analyses. They created either
scientific posters (UNA V) or slide presentations (CMU), and at the end of the semester, we hosted a video-conference using Zoom where students at CMU and UNA V were able to share their research with each other. Throughout the semester, students at each institution investigated the phonological theme of vowel harmony as a case study in phonology. For context, we next describe our respective courses and student demographics, which were assessed by a survey distributed to the students at the beginning of the semester.

**CMU Phonetics & Phonology II.** Phonetics & Phonology II is a third-year course that is part of the linguistics major offered through the Philosophy Department at CMU. It is not required and does not serve as a prerequisite to any other courses. The prerequisites for this course are Nature of Language, an introductory linguistics course, and Phonetics & Phonology I, both of which are required for the linguistics major. During Spring 2019, a total of fourteen students were enrolled in Phonetics & Phonology II: five were in their second year, six were in their third year, and three were graduating seniors. Six of the students did not have an extensive background in statistics, though students in the Dietrich College of Humanities and Social Sciences (five) are required to take a first-year statistics course, as are students in the Science and Humanities Scholars program (two); six students were declared Mathematics (two) or Computer Science (four) majors, and so had significant technical background. While many students had taken several other linguistics courses, one student had only the minimum prerequisites. All students were native speakers of English, though some were heritage speakers of other languages. Some students had limited experience with research, but none had carried out an acoustic study prior to this course. Zsiga 2013 was used as a textbook.

**UNA V Phonetics & Phonology.** Phonetics & Phonology at UNA V is a third-year required course as part of the Philology major; it does not serve as a prerequisite to any other courses. As opposed to university contexts in the United States and elsewhere, students in Spain receive classes only in their major. That is, there are no general requirements outside of the students’ fields of study. During the Spring 2019 semester, fifteen students were enrolled in the course. Of the fifteen, three were native Italian speakers, one was a native speaker of American English, and the remaining eleven were native Spanish speakers. Only three had prior experience in quantitative analysis and/or statistics, which they had received in a previous course, Language and Communication, while conducting a similar research project with the same professor (one of these three is actually a research assistant at the speech laboratory where data collection and analysis took place). While all had taken prior courses in linguistics as part of their Philology major, the majority were more interested in literature than in the scientific study of language. Hualde 2014 was used as a textbook.

**2.2. The Collaborative Research Project and Presemester Preparation.** In keeping with our goal for the research project to be collaborative at the faculty level, we implemented broadly the same study in each of our classes. At CMU, the students carried out an acoustic study on speakers of English that investigated various hypotheses related to vowel-to-vowel coarticulation; at UNA V, the students investigated the same hypotheses on speakers of Spanish, but with ultrasound.

The topic of vowel-to-vowel coarticulation was chosen for several reasons. First, vowel formants are typically taught early in (acoustic) phonetics, but only in terms of inherent vowel quality. The phenomenon of vowel-to-vowel coarticulation thus pushes students to understand vowel formants dynamically rather than statically. Second, there are
numerous scripts for acoustically measuring vowel formants, and the position of the
tongue can be readily seen in ultrasound, making the study appropriate for students at
both institutions. Third, vowel-to-vowel coarticulation has been linked to various phono-
logical phenomena, such as vowel harmony (Przedziecki 2005) and diachronic vowel
raising in Spanish (poder > pudiera: raising of /o/ to /u/ before /i/). These facts allowed
for the simultaneous examination of related phonological phenomena.

In order to have the time to cover core content as well as the research project, various
aspects of the project had to be ready to go before the semester began. For example, at
CMU, the Institutional Review Board (IRB) protocol had to be completed and ap-
proved; once the semester started, students completed their IRB training, and an
amendment to the IRB was submitted to add the students as co-investigators; this did
not need to be done at UNA V because of an ongoing IRB protocol for a research project
financed by the Spanish Ministry of Science and Innovation.

Motivated again by practical considerations, we had articulated the hypotheses and
come up with the word lists before the semester began; as we explain in §2.5, the skills
of hypothesis generation and corpus creation were therefore taught with an approach
we call ‘simulation’. This was done so that students at CMU could begin recording sub-
jects; at UNA V students were themselves the subjects2 and needed time to process the
ultrasound data.

2.3. SPRING 2019 INITIATIVE: ORGANIZATION OF CONTENT AND PHONOLOGICAL
THEME. We can divide the Spring 2019 implementation into various components: (i)
‘core’ content, which had to be covered whether or not it was directly related to the re-
search study or phonological theme; (ii) the phonological theme; and (iii) the research
study. While the specifics of timing and content differed between us, we both opted to
front-load much of the core content in anticipation of the time-consuming data analysis
that would take up the bulk of the latter part of the semester. As mentioned, neither of
our courses is a prerequisite for other courses, so we did not have specific prerequisite
content that needed to be covered, but we address this concern for those interested in in-
tegrating CARE into courses that do function as prerequisites in §4.3.

For example, at CMU, the material from chapters 1–8 of Zsiga 2013 was covered in
the first half of the course, which itself was divided into roughly three parts:

• **Weeks 1–3:** We focused on review (articulatory phonetics, what formants are, and
  the basics of phonological analysis) and introduced the vowel harmony data sets
  that would become part of the phonological theme of vowel harmony; in the mean-
time, students completed their IRB training.

• **Weeks 4–6:** Acoustic phonetics, covering both theory (chapters 6–8 from Zsiga
  2013) and practice (chapters 1 and 4 of Ladefoged 2003); during this period, stu-
dents were responsible for recording participants and beginning segmentation,
  which were taught in class and in extra how-to lab sessions.

• **Weeks 7–8:** While students wrapped up their segmentation, we tackled some of
  the background literature for the phonetic research study.

As can be seen from the course outline provided in the supplementary materials (which
can be accessed at http://muse.jhu.edu/resolve/146), the phonological theme was partic-
ularly important in weeks 7 and 10–12, when it was used as a case study to showcase
how different phonological theories handle the same data. That is, as students worked
through chapters 12–14 in Zsiga 2013, covering SPE-style rules, autoSEGMENTAL

2 Their data were collected before they knew the topic of the research study.
Phonology, and Optimality Theory, in-class activities asked students to develop analyses of the vowel harmony data sets using those theoretical approaches. In this way, the phonological theme was tied into the core content. The last few weeks of the semester were devoted exclusively to working on data analysis.

At UNA V, vowel harmony was introduced early, though not extensively, in the text (Hualde 2014) and was directly related to vowel-to-vowel coarticulation. However, the students were presented with enough information in the text about autosegmental phonology, optimality theory, and Articulatory Phonology to perform beginning-level analyses within each framework. Working in groups, the students were walked through the assumptions that each theoretical framework supposes about the phonology and were instructed to provide an analysis of vowel harmony, using the diachronic data from Spanish. They were then asked to compare and contrast the three frameworks and point out the strengths and weaknesses of each approach. As a final question on their exam, they were asked to reflect on the results of their research study and to return to the question of vowel harmony and diachronic change. The question read: ‘Reflect on the results of your study on vowel-to-vowel coarticulation in Spanish and tell how each phonological model (Autosegmental, Optimality Theory and Articulatory Phonology) would explain the phonetic basis for the vowel change in Spanish (i.e. by way of features, constraints, articulatory timing). Which model seems to better justify a phonetic basis for sound change?’ Though the model evaluation was difficult for many, all were able to relate their results to the process of vowel harmony and diachronic change, as well as to provide an initial sketch of how they thought phonological changes could be induced by small, successive phonetic modifications over time.

2.4. Implementing collaboration and fostering ownership. Linguistics as a discipline is increasingly collaborative (José & Berti 2017), and we believe that this collaboration can and should extend into the classroom. Student-student collaboration, namely, group work, is the most common form in the classroom, but in the CARE approach this is, ideally, just one of three types of collaboration, with faculty-faculty and faculty-student collaboration being equally important. We brought our (the faculty’s) collaboration on the research study into the undergraduate classroom by having students in both of our classes carry out the same study on different populations. Training our students to be, effectively, our research assistants fostered the faculty-student collaboration inherent in the CARE framework.

Group work is a long-standing feature of many classrooms, and there is a long literature supporting its effectiveness. First, group work is often used to break the monotony of instructor lecturing; both personal experience and discussions with other teachers strongly suggest that students appreciate the opportunity to discuss content with their peers during class hours. Moreover, since group activities often incorporate active learning, their pedagogical effectiveness is well founded. However, although in-class group activities are generally well received, long-term group projects are often met with trepidation and apprehension. One of the most common concerns from students is the inequitable distribution of work, and the fear that some students will not do their fair share (van Hattum Janssen 2014); some literature reports that only 50% of students deem group work to be a good learning experience (LaBeouf et al. 2014).

Group work appears to be better received in the context of research than it is in the context of regular course work. For example, in a three-year, qualitative study on the benefits of undergraduate research opportunities across a range of disciplines, Seymour et al. (2004) specifically discuss the value of both faculty-student and student-student collaborations. Based on interviews with students who had participated in undergradu-
ate research (outside of the classroom), they report that students appreciate the opportunity to work as colleagues with faculty members and greatly value the trust and reciprocity that characterizes such a relationship; see also Hunter et al. 2007 and Charity Hudley 2018 for similar findings. Further, students report drawing significant support from their student research peers in undertaking such projects.

In the Spring 2019 initiative, we took an approach to student-student collaboration that we found worked particularly well, balancing individual responsibilities with the benefits of a collaborative environment. Each class was divided into four groups, one for each hypothesis. Before commencing the study, students were instructed to complete a Google Form that was used to assess students’ preexisting skills, working style, and their interest in the project; a PDF of the survey is included in the supplementary materials. At both institutions, students were divided into groups in such a way as to distribute different skills and working styles evenly. For example, at CMU, each of the four students who were majoring in Computer Science was put into a different group, thereby distributing their skills across the groups. Similarly, students who responded that they were particularly strong in leadership and making sure everybody stayed on track were distributed across the groups. Balancing the various skill sets and creating the groups was not a trivial task, but given the results discussed below, we found it was well worth the effort.

When asked about individual strengths students felt they could bring to the project, answers varied, but some common responses were ‘I’m very organized’, ‘I have a good sense of humor’, and ‘I’m creative and I like to speak in public’. When asked about which skills they wanted to hone during the course of this project, nearly all of the UNA and several CMU students referenced their insecurities regarding statistics and working with numbers in general. When asked about their individual weaknesses, students were quite honest, being frank about whether they tended to do work at the last minute and needed someone to be ‘on top of them’ in order to complete work on time, or admitting that they were disorganized and worried about losing equipment. In fact, while responses about individual strengths and weaknesses varied dramatically, one question yielded strikingly similar responses: ‘What are you most nervous about?’. Nearly all of the students who indicated that they were nervous voiced the worry that they would somehow ‘mess up’ the project. In other words, students were invested in doing a good job from the beginning, reflecting our belief that students are inherently motivated to do well when they are entrusted with actual responsibility. Furthermore, because students were so refreshingly honest, every attempt was made to distribute the groups based on these strengths and weaknesses. At CMU, this was communicated to students (in general terms) when the groups were presented to them, and students were encouraged to share their strengths and weaknesses with each other during the first group meeting. This conversation quickly established the various roles of various group members, and we found that, because students were upfront about their strengths and weaknesses, other group members readily stepped in to fill the gaps without resentment. For example, students joked about one group member being ‘the boss’ or ‘the enforcer’, and this dynamic seems to have eliminated the resentment that typically arises when someone’s weakness is disorganization or lateness. Indeed, we emphasize that instructor-organized groups created in this way were perhaps the most effective component of making the group work successful. At the conclusion of the course, students were asked to complete an exit survey (included in the supplementary materials), which served to provide us with feedback on their experiences and to indicate any issues with the distribution of group work. There were virtually no problems with the division of labor, and many of the students expressed relief that the work was distributed so equi-
tably. Several students indicated that though they were initially dreading the group project, ultimately their group worked extremely well together.

The other consistent worry expressed by our students in the intake survey was that timelines would not be respected by all group members equally. As this was our concern as well, we took several steps to mitigate this. First, in order to ensure that the research project could be carried out, it was important that certain steps were completed in a timely fashion, specifically: completion of CITI training for IRB purposes, finding and recording participants (two per student at CMU), and segmenting the data. These steps were completed individually and had to be completed on time in order for students to pass the research portion of the course. The penalty for noncompletion was set so high precisely because failure to complete these steps would prohibit the rest of the class from being able to do the research study.4

When it came time to analyze the data, interpret the results, and write up final papers and presentations, students worked in the groups created by the instructors. At this stage, students were encouraged to divide the work based on their skills, and the evenly distributed existing skill sets of the groups proved instrumental to the success of the projects. For example, students who had stronger writing skills tended to take on the writing of the final paper, while students who were more comfortable working with code manipulated the provided R scripts to create graphs. This feature of the group work was noted as being particularly valuable and appreciated in the end-of-term survey.

Throughout the semester, at each stage of the research project, students were required to submit short reflections on that stage of the research, briefly describing what they did and what they learned, what went well, and what difficulties they faced. This not only encouraged students to be reflective in their engagement with research, but also provided valuable feedback to the instructors for future implementations. Furthermore, because each stage required students to submit individual reflections, group members had to communicate with each other, explaining what each member was doing to move the research forward. At UNAV, a survey designed to measure their progress with specific skills was administered when most students were finishing up labeling and segmentation. When asked to contextualize the tasks within the broader research project, all students were able to articulate the connection between the individual tasks, the research questions, and the final results.

Making collaboration such an integral part of our approach ties into our beliefs about how to effectively teach research skills: (i) research skills can be taught; (ii) where they are difficult to teach, they emerge naturally within a collaborative environment; and (iii) they are individual, but for public use. The first of these beliefs boils down to the claim that research can be broken down into identifiable skill sets that can be explicitly taught in the classroom setting. Certain skills, such as leadership, are more difficult to teach explicitly, but in this case we believe that such skills emerge naturally in an appropriately structured collaborative environment. Finally, while it is certainly true that certain skills are more well developed in some students than in others, the collaborative environment allows for such individual strengths to be made available to others.

3 CITI = Collaborative Institutional Training Initiative
4 A referee asks how we dealt with situations in which students could not complete the data-collection portion on time. In this case, we think that being flexible and accommodating is of the utmost importance, and so would work with the student to find a solution that worked for them, either by having them contribute data at a later date or take on extra work at a later time in the semester (as was done for a student at UNAV). While we have not dealt with this situation, if neither of these options was possible due to the circumstances, then we would simply let it slide, assuming that the remainder of the work was done to a satisfactory degree.
In the following section we discuss how our approach incorporates active learning, and indeed active learning was an integral part of the project. Nevertheless, it is important to keep in mind that active learning, as it has been outlined in the work referenced here (specifically, Prince 2004, Chi 2009), falls short of a complete framework for learning to perform research, as we envisage it. While the tenets of various active learning frameworks are appropriate and exhaustive for learning a wide range of skill sets, they do not posit action in a larger context. For a more comprehensive learning environment, and for more robust learning to occur, active learning must be encapsulated in an experience.

The importance of creating a learning experience through action is thus critical to the CARE approach (Kolb 1984). Experiential learning, as per Kolb (1984), unfolds through experiences, conceptualization, experimenting, and reflection, a process that is cyclical and ongoing. Students learn when they perform actions within an experience and observe successes and failures. However, for meaningful learning to occur—where we interpret ‘meaningful’ as learning that will lead to a change in behavior or ideas—students must make reflective observations of the experience. It is during this stage that students reflect on their successes and failures and identify ways to improve or alter the experience in the future, and to learn from others. After this reflective observation has been performed, the students can then decide what they will do differently next time and set forth a strategy by which to implement that change, motivating the various reflection activities throughout the semester.

2.5. Active Learning in the Context of Authentic Research. It is well known that active learning improves student learning, as shown by Freeman et al. (2014) in a meta-analysis of 225 studies on exam scores and failure rates in science, engineering, and mathematics. Much of the evidence for the benefit of active learning comes from education studies in STEM fields, but there is a sizeable literature showing that active learning is effective in the humanities and social sciences as well (Faust & Paulson 1998, Lamb & McCombs 1998, McCarthy & Anderson 2000).

Engaging in authentic research is inherently active: it is not possible to generate hypotheses, collect and analyze data, and interpret results without being actively involved, and so active learning is a core component of the CARE approach. While the term active has been used in various ways, one broadly accepted definition is that active learning is ‘any instructional method that engages students in the learning process’ (Prince 2004). Crucially, active learning refers to in-class or formative (rather than summative) activities, and so excludes traditional instructional elements such as homework or readings to be done outside of the classroom, though of course such tasks can be designed to embed an active-learning component. The degree to which a class incorporates active learning exists on a spectrum. At the one extreme is the traditional lecture, with little to no active engagement by the students, except perhaps in the form of note taking or occasionally asking questions. At the other extreme is the flipped classroom, where content that would traditionally be presented during class is instead provided to students ahead of time (e.g. in the form of videos) and class time is devoted to problem solving (Bishop & Verleger 2013).

A narrower definition of active learning is offered by Chi (2009), who distinguishes between active, constructive, and interactive learning. Crucially, each of these concepts is defined in terms of the observable actions of the students during the learning process. According to this framework, learning is active if students are physically doing something: using props, drawing diagrams, paraphrasing, pointing, and so forth. Learning is furthermore constructive when ‘learners produce some additional outputs … [that] often (but not always) contain new content-relevant ideas that go beyond the
information given’ (Chi 2009:76): for example, explaining the meaning of a passage of text. As Chi points out, constructive learning subsumes active learning. Finally, learning is interactive if there exists substantive dialogue with another person. The CARE framework provides opportunities for all three kinds of learning; although distinguishing active, constructive, and interactive learning can be helpful, we continue to use the umbrella term ‘active learning’, as it is more widely used and understood.

In the context of a research project, active learning is most obviously and straightforwardly exemplified by students when they are FULLY ENGAGED with the decision-making process, as they are, for example, while segmenting acoustic data. That said, it is not possible to involve students directly in all stages of a research project, as there is simply not enough time in a single semester, particularly when other course material must be covered as well. One important component of the CARE framework is not only deciding when and how to implement active learning strategies but, crucially, also deciding when not to. We refer to this as BLACKBOXING: when students are given a tool or concept as a ‘black box’ to use without requiring that they engage more directly with it. For example, we did not expect students to learn Praat or R scripting as part of our course, and so scripts were provided to students, with no expectation that they would modify them (though some students took the initiative to do so anyway).

Intermediate between blackboxing and full engagement is what we refer to as SIMULATION: guiding students through the thought process that underlies previously made decisions. Importantly, simulation still requires active engagement, and it is a way to incorporate active learning even when full engagement for that stage of the research project is not possible. For example, hypothesis and stimuli generation were done prior to the beginning of the semester, but course components were designed to simulate hypothesis generation, either through in-class activities and discussions, or through written assignments. Examples are provided in the supplementary materials.

In the following section we provide a summary of the research-based and transversal skills we feel were acquired during each phase of the research project, and indicate which of the three methods was employed in the Spring 2019 initiative: full engagement, simulation, or blackboxing.

3. ARTICULATION OF SKILLS IN RESEARCH. There is no question that students have a lot to learn by doing research, and that in doing research, students have the opportunity to develop new skill sets. Nonetheless, we ask what, specifically, are the pedagogical goals of the instructor in having students do research? In fact, why bother taking up precious class time incorporating research into an undergraduate class, given that only a minority of the students will pursue careers in research, much less graduate school in linguistics?

Our position is that although many of the skills that the students acquire over the span of the course are research-based, there are many non-research-based, or TRANSVERSAL, skills that they acquire as a result of engaging with original research. For example, the act of performing research in any discipline involves transforming a vague question into an empirically testable project. First, this transformation involves a series of critical thinking skills (observation, analysis, interpretation, reflection, evaluation, inference, explanation, problem solving, and decision making, among others) that are valuable in their own right, whether in the professional or personal realm. Second, this transformation involves an understanding of how the hypothesis maps to specific measures and methodologies, explicitly delineating both the boundaries of current knowledge (which we are trying to change with the research study) and the limitations inherent to the scientific method and statistical reasoning. Making this process explicit
for students has value far beyond the phonetics/phonology classroom, providing students with the experience to understand what it means to tackle big problems scientifically, regardless of discipline. Finally, this transformation also changes the student because they learn that what may seem at first to be an ambiguous amalgam of ideas can be methodically broken down into manageable and executable tasks; see Hunter et al. 2007 for discussion of how undergraduate research transforms students and helps them see what it takes to ‘become a scientist’.

The appreciation for scientific literacy does not, in and of itself, justify why research must be learned experientially. After all, the aforementioned skill of transforming a vague question into an empirically testable hypothesis was taught to the students in Spring 2019 by simulation, and one might wonder whether the entire research process could not be taught solely through simulation activities. We argue that the answer is ‘no’: certain skills cannot be acquired by simulation, but must be experienced to be learned. To illustrate, consider the process of segmenting and analyzing data. We could, of course, take an already collected corpus of audio or ultrasound data and teach the students in about one or two class sessions how to segment the data. But when data segmentation is encapsulated in a context, or experience, things get messier, for the better (at least for learning). For example, some data might get lost due to technical error (e.g. files are accidentally not saved, or mysterious ‘corruptions’ occur with no possibility of retrieval, etc.), while other data may present unforeseen challenges to segmentation. This creates various issues that the students have to grapple with, say, because the data are no longer evenly distributed, or perhaps a whole hypothesis is in danger of having to be eliminated. While these challenges are project-specific, problems like this, and many others, arise continuously over the course of research. Solving (or at the very least dealing with) these problems by creating strategies to reorient or redirect the question so as to finish the project satisfactorily leads the student to first think through the repercussions of the loss of data, consider how that loss will affect the whole research chain, foresee how the fix will subsequently alter the project, and make a decision about the best strategy. This leads to a deeper understanding of the process of segmentation and contextualizes the different activities of research in a holistic way. In this way, segmentation is not just a skill the student acquires: it is a skill they understand and are able to reflect on.

To put it another way, part of the value of incorporating authentic research into the classroom is the opportunity to guide students through the difficult and messy process of research not going as planned. In the Spring 2019 initiative, that component was the data analysis and segmentation, but in another implementation, it might be a different stage, such as determining the correct measures or interpreting the results. For example, in Spring 2021 a combination of factors (most crucially the experience of teaching remotely due to the COVID-19 pandemic) led us to make different decisions. Unfortunately, again due to restrictions that COVID-19 placed on us (including institutional restrictions), as well as the start dates of our respective semesters being a month off, we were unable to implement a full-fledged collaboration between the classes at CMU and UNA V in Spring 2021. In order to address these difficulties but still retain the spirit of CARE, we decided that the students at CMU would begin by reading the literature on vowel-to-vowel coarticulation, critiquing the Spring 2019 studies, and then as a class decide how to proceed, with two options available: students could analyze data that had been collected in Spring 2019 but was not analyzed, or they could design a perception

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5 At CMU, Phonetics & Phonology II is offered only every other year.
study using the acoustic data from the first group. The second author provided some
guest lectures to the students at CMU, and the students at UNA V were encouraged to
participate in the research study for extra credit if they wished. Note, therefore, that
skills such as recruiting and recording participants were not taught through full engage-
ment in the Spring 2021 version; instead, students fully engaged with the generation of
hypotheses and with study design.6

Finally, recall that an important component of the CARE framework is that skills are
developed in a collaborative environment, and as a result, certain skills specific to col-
laboration (e.g. conflict resolution) and skills in communication, organization, and
leadership are honed throughout the semester.

In Table 1, we have identified the skill sets—both research-based and transversal—
acquired at each stage of the research process. Though this list is certainly not exhaus-
tive, we hope that it might prompt instructors to carefully consider the pedagogical
goals they have for their students, incorporating the principles we have outlined here in
such a way as to center their projects around specific skill sets. Table 1 also identifies
the strategy that we chose to implement in the classroom for each research stage. Note
that in some cases, the research-based and transversal skills are closely related. Indeed,
under ‘statistical analysis’, we include the same skill, ‘Understanding the importance of
experimental design in drawing conclusions’, in both columns. While this skill is obvi-
ously related to research, it is also a skill that helps students be critical consumers of in-
formation in the world at large, as they are inundated with information and study results
from a variety of disciplines.

4. PUTTING CARE IN CONTEXT.

4.1. Undergraduate research. Boyer (1990) articulated a vision of academia that
places equal value on the scholarship of discovery and the scholarship of teaching (to-
gether with two other components: the scholarship of integration and the scholarship of
application). In particular, Boyer argues that the scholarship of teaching is not just about
the transmission of knowledge, but also about the extension and transformation of
knowledge. While engaging students in authentic research is not the only way to accom-
plish this, it is one of the most direct ways. The 1998 Boyer Commission Report proposed
that research experiences should form a strong component of undergraduate education,
particularly in research-oriented universities, and since then there has been an explosion
of undergraduate research experiences offered at universities in North America (Willison
& O’Regan 2007). The Association of American Colleges & Universities identifies un-
dergraduate research opportunities as being a ‘high-impact’ educational practice, as are
collaborative assignments and projects (Kuh 2008). In contrast to the North American
situation, there is not a tradition of undergraduate research in Europe generally, nor in
Spain more specifically. Undergraduate research has started to become more popular in
recent years due to advances in experiential-based pedagogical frameworks (Dewey

6 The differences in implementation between Spring 2019 and Spring 2021 have implications with respect
to authorship and credit. Following the Spring 2019 implementation of the research study, we continued to
work with one of the students from CMU and submitted an abstract to the 2020 annual meeting of the Lin-
guistic Society of America, which was accepted for presentation (Bjorndahl et al. 2020). We credited the stu-
dents from CMU in a footnote (we presented only acoustic data), but Kade Stewart was credited as an author
because of his continued involvement in the preparation of that poster. We felt that crediting the students in a
footnote was appropriate because, in that implementation, the students were not directly involved in the de-
sign and creative process (namely, hypothesis and stimuli generation), in the creation of the scripts for data
analysis, or in the writing of a journal submission. In the Spring 2021 implementation, students were advised
that authorship would depend on their degree of involvement in the design and write-up of the study, and that
this would be an ongoing conversation. Ultimately, due to various factors related to teaching during the pan-
demic, little progress was made on the study in the Spring 2021 semester; a few of the students opted to con-
tinue working on it over the course of the summer, and in that case, will be considered coauthors.
### Research-relevant skills

**Hypothesis generation**
- Understanding the existing state of knowledge regarding the problem at hand
- Acquiring sufficient background knowledge (i.e. command of relevant background literature)
- Understanding how available methodologies may provide answers to research questions
- Understanding the relationship between specific measures and hypotheses

**Corpus creation**
- Understanding the hypothesis sufficiently to create a corpus
- Consolidating background (linguistic, phonological, phonetic) knowledge so that the corpus is sufficiently controlled
- Relating measures to corpus items (e.g. understanding that word-initial voiceless stop closure duration cannot be measured in word-initial voiceless stops in a purely acoustic study)

**Data collection**
- Using experimental instruments
  - Properly caring for instruments
  - Adhering to lab procedures
- Interacting with human subjects
  - Following IRB protocols
- Testing experimental setup (e.g. sound levels)

**Data analysis: segmentation**
- Determining consistent criteria for segmentation and exclusion of tokens
- Applying knowledge about acoustic correlates of segments
- Operating software (e.g. Praat)

**Data analysis: measurements**
- Determining how to operationalize measurement procedures (e.g. window type/size)
- Writing/modifying scripts for extracting relevant measures

**Statistical analysis**
- Using the appropriate statistical tests for hypothesis/measures
- Understanding the importance of experimental design in drawing conclusions

**Write-up/presentation of results**
- Interpreting data
- Articulating how results relate to hypothesis and measures
- Creating appropriate tables, graphs, and figures to convey information

### Transversal skills

- Actively engaging with complex material required in order to ask questions and formulate hypotheses
- Translating vague ideas into quantifiable questions
- Creativity
- Attention to detail
- Organization
- Interacting with people professionally
- Collaborating with other experimenters (shared materials and space)
- Time management
- Keeping detailed records (e.g. regarding excluded tokens)
- Time management
- Attention to detail
- Decision making
- General scientific literacy
  - Understanding role of statistics in scientific inquiry (e.g. ‘rejecting the null’)  
  - Understanding how experimental design allows one to draw conclusions
- Presenting technical material
- Expositional writing

*Spring 2019: simulated through written assignments and discussion*

*Spring 2019: students collected all data*

*Spring 2019: students performed segmentation; Praat scripts provided (blackboxed)*

*Spring 2019: Praat scripts for measure extraction provided (blackboxed)*

*Spring 2019: in-class activities to teach basic statistical methods (active learning); R scripts provided (blackboxed)*

*Spring 2019: interpretation of data, write-up, and presentation of results done by students, both during in-class activities and with groups outside of class time (active learning)*

| Table 1. Skills acquired through the research process. |
1938, Kolb 1984, Lewis & Williams 1994), but it has not traditionally been fostered in the Spanish educational system. Our discussion regarding the efficacy and assessment of undergraduate research therefore primarily comes from countries in which there is a robust tradition of undergraduate research, primarily the United States but also other countries such as Australia and Canada.

Undergraduate research usually takes one of two forms: undergraduate research experiences (UREs), which are offered outside of courses and can last multiple semesters, and course-based undergraduate research experiences (CUREs), which are offered through courses (Linn et al. 2015). As Corwin et al. (2015) discuss, CUREs instantiate various learning theories wherein learning is taken to be both cognitive and social, such as social learning theory (Bandura 1971) and situated learning theory (Lave & Wenger 1991). Within these models, students learn by taking part in an authentic activity (e.g. research), which is embedded in a social context (i.e. the classroom), and CARE lies firmly in this tradition. Nagda et al. (1998) argue that one of the main benefits to engaging students in an authentic research study is that it integrates students into the core university mission, and Bangera and Brownell (2014) suggest that CUREs can make scientific research more inclusive. For example, Charity Hudley (2018) details a cross-departmental program—including Linguistics—that she founded and directed at the College of William & Mary in order to increase undergraduate student participation in research, and specifically targeted to underrepresented students. The results of this program suggest that the inclusion of undergraduates in such programs positively supports their academic and professional trajectory and serves to reinforce inclusion and equity efforts. Similarly, Napoli et al. (2022) discuss the benefits of their implementation of a senior thesis. It is therefore widely believed that undergraduate research opportunities impart many benefits to students, such as increased student interest in the field, enhanced career preparation and clarification of career path, development of valuable skill sets, critical thinking, understanding the research process, and shifting the learning paradigm from passive to active (Seymour et al. 2004).

In many cases, student participation in undergraduate research through UREs—or even, at times, through CUREs—is controlled, because students must either apply or be invited to participate. As a referee points out, such research experiences are often available only to students who have the time and/or flexibility in their course plan to participate in extracurricular research, receiving credit in the form of course credit only; this has a discriminatory effect on students who cannot take on such ‘extra’ initiatives because, for example, they need to work or have additional responsibilities beyond their schoolwork. As a result, the advantages that come from participating in a research study are generally limited to those students who are already experiencing some measure of success in their undergraduate experience. Bangera and Brownell (2014) detail the ways in which traditional research opportunities can be discriminatory and suggest that CUREs can make research more inclusive, since the only requirement is that students have taken basic prerequisite courses. In our case, the prerequisites are quite minimal, and the courses are counted toward students’ respective majors. By incorporating undergraduate research into core classes, CARE contributes to making both linguistics (as a field) and

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7 We would be remiss if we failed to point out that while our approach is intended to be more inclusive to all students because it is incorporated directly into core classes of the major, we have not explicitly implemented strategies to recruit and mentor underrepresented students, nor have we integrated our approach explicitly with our respective university infrastructures. In light of Charity Hudley’s call to linguists to promote such endeavors at their institutions through the lens of undergraduate (linguistic) research, we identify this as an area of further development.
research (as a practice) more inclusive. One other, albeit anecdotal, bit of evidence in favor of expanding the availability of undergraduate research is that in our experience, grades do not necessarily correlate with success as a researcher, casting at least some doubt on the utility of minimum GPA requirements for allowing students to engage in research. Both of us have found that the students who were the most effective researchers—whether because of how they tackled questions, their organizational skills, their ability to synthesize data, or the facility with which they drew conclusions from the results—were not necessarily the students who performed the best on tests, problem sets, or other core content.

In spite of the widespread and long-standing belief that undergraduate research benefits students, until recently this belief has had little empirical support. Indeed, addressing this concern is the main motivation underlying the research reported by Seymour et al. (2004), who argue that in spite of the proliferation of research opportunities, few have been supported by evidence that these opportunities accomplish what they set out to do. Since then, there has been a proliferation of research that seeks to understand what specific benefits undergraduates accrue in their participation in research. For example, based on survey results from 1,135 undergraduates at forty-one undergraduate institutions, Lopatto (2004, 2007) found that research in the sciences enhanced the undergraduate experience in terms of various learning gains, particularly with respect to lab techniques and the research process. Additional literature suggests that students who have participated in undergraduate research experiences show an increase in their GPA, even when previous ability was controlled for (Fechheimer et al. 2011); in contrast, see Taraban and Logue (2012), who suggest that research experiences do not benefit all undergraduates equally.

In order to at least partially assess the perceived benefits and drawbacks of implementing undergraduate research opportunities in the phonetics/phonology undergraduate classroom and curriculum, we administered surveys at the beginning and end of the semester, in part to gauge student interest, background, and preconceptions initially, and then to receive feedback on the experience at the conclusion of the project; these surveys form the basis of §5.

4.2. UNDERGRADUATE RESEARCH IN PHONETICS AND PHONOLOGY. Linguistics has its own tradition of undergraduate research, as evidenced by the numerous annual undergraduate conferences held across North America, the number of which is growing every year. For example, a search on Linguist List for all conferences that feature the word ‘undergraduate’ in the title yields ten undergraduate conferences in 2018, up from only two in 2003, the earliest year for which data are provided. In Spain, however, linguistics is usually studied as a subfield of Philology, and thus its study is relevant only in the context of analyzing texts (mainly literature), though historic texts are often also analyzed linguistically. Empirically based group research is nearly nonexistent in this context. In fact, based on an informal perusal of several linguistics department websites, many professors base final grades nearly exclusively on a comprehensive final exam, which may count for up to 70% of a student’s final grade.

In North America, many linguistics department websites specifically mention undergraduate research opportunities, such as getting involved in a faculty member’s lab or doing a senior thesis. Indeed, a Google search for ‘undergraduate research linguistics’ shows that many linguistics departments provide numerous opportunities for undergraduates to participate in authentic research, often in teams. To list but a few notable examples: at Yale University, students have multiple opportunities for independent research in a wide range of subfields with several faculty, and for some collaborative projects as well,
such as participation in the Yale Grammatical Diversity Project (https://ygdp.yale.edu/) and opportunities to work with researchers at Haskins Laboratories; Charity Hudley (2018) details undergraduate research opportunities at the College of William & Mary, as previously mentioned; at Georgetown University there are dedicated opportunities for undergraduates to work with graduate students on original research projects, instantiating a cross-generational collaboration of a different nature; the Speech Production Lab at the University of Michigan regularly involves undergraduates in research projects, and it is particularly noteworthy that they emphasize the interdisciplinary and especially inter-generational aspect of their lab (see Cook et al. 2022 for discussion). Finally, Napoli et al. (2022) discuss how they take advantage of the shared Linguistics Department at Bryn Mawr, Haverford, and Swarthmore Colleges to create a community of scholars for their students who undertake research projects for a senior thesis.

These existing models (among many others) point to a general recognition of the value in providing research opportunities to linguistics undergraduates, in keeping with the broader academic mission to do so in North America. Furthermore, initiatives such as the Speech Production Lab at the University of Michigan suggest that a shift is taking place toward recognizing the important contributions that undergraduates can make to projects as research peers. We are encouraged by these initiatives and believe that CARE is a natural complement to these approaches, being particularly suitable for smaller departments and majors.

Turning our attention specifically to undergraduate education and research in phonetics and phonology, CARE is part of an ongoing broadly international interest in teaching phonetics and phonology by way of engaging students in authentic research in the undergraduate classroom. This interest is manifest in community-wide efforts to simultaneously raise the general academic level in phonetics and phonology courses as well as in the development of reproducible classroom materials for use by community members. A recent surge in incorporating undergraduate research into the phonetics and phonology classroom is evidenced by the growing presence of pedagogical themes in mainstream phonetics and phonology conferences, such as the 27th Manchester Phonology Meeting workshop ‘Teaching phonology: The state of the art’ (https://sites.google.com/view/yunikim/mfmfringe), as well as the ‘Pedagogical approaches to laboratory phonology’ session at the 17th International Laboratory Phonology Conference (https://sites.google.com/view/labphon2020pedagogy/). These special conference sessions have served to unite the community around all questions pedagogical, as well as to highlight the vast differences that exist vis-à-vis how research may be incorporated into the phonetics and phonology classroom. For example, one recurring topic and question many phoneticians/phonologists are concerned with is how to implement research-based education in large classes or in situations where students have disparate skill levels. While CARE mitigates the limitations of class size to some extent (e.g. by modifying the mode in which the material is presented, namely, by deciding which material will be blackboxed, simulated, or experienced through full engagement), it is hard to envision how CARE would be appropriate for very large classes, around thirty students or more. In such cases, it may be possible to involve students in only a portion of the research; see, for example, Beth MacLeod’s initiative for addressing research in large undergraduate courses (MacLeod 2020).

In a similar vein, as we outlined earlier, one of the objectives of CARE is to help students develop transversal, non-research-based skills by way of group dynamics. We see this as part of the broader landscape in shifting pedagogical concerns regarding the development of new tool kits for an ever more globalized world and changing job market,
and the recognition that traditional educational experiences are no longer sufficient. For example, even at the fairly niche LabPhon 17 satellite workshop “Pedagogical approaches to laboratory phonology” (which, for full disclosure, both authors were involved in organizing), we saw a range of pedagogical issues and initiatives described, including Howell and Baird’s presentation (2020) on “Information literacy in the laboratory phonology classroom” and Blaylock’s paper (2020) on teaching phonetics and phonology using different singing techniques. We therefore consider CARE to be part of the current wave of interest in and enthusiasm for novel methods in teaching linguistics more generally, and in phonetics/phonology more specifically. Our articulation of CARE as a pedagogical framework is an attempt to ensure that the development of new teaching practices is founded in a scholarly and reflective approach to teaching, and is grounded in the broader SoTL community.

4.3. CARE as a way to teach linguistics. The CARE framework is intended to promote a general educational perspective that we hope will become broadly accepted and implemented in linguistics education, and particularly within laboratory phonology. Linguistics has long grappled with how best to teach its subject matter. For example, Pullum (1984) discusses two views of how linguistics should be taught (with particular focus on syntax), summarizing a position that David Lightfoot had discussed in the London Times Higher Educational Supplement in 1982. The first view (which Pullum characterizes as the predominant British view at the time) is that “[s]tudents should be introduced to the study of language by taking a fast Cook’s tour of all its aspects, getting to know “the field”” (Pullum 1984:152, citing Lightfoot). We might call this the survey view, though Pullum dubs it the ‘If-it’s-Tuesday-this-must-be-glossematics’ way of teaching linguistics. In contrast, the second view, which was in fact Lightfoot’s proposed alternative, is to ‘train students in one research programme, a programme which tries to develop a detailed answer to one central question about language (e.g. how it is attained by children or how is it used by poets, how can it change, or how does it reflect cultural values?)’ (ibid.). Pullum calls this an investigation-oriented course structure, a name that seems fitting to us as well. Pullum further identifies two subtypes of this view: the ‘Here’s-a-proposal-that-makes-sense-to-me’ course structure (in which the instructor advocates for a particular proposal) and the ‘Think-of-a-proposal-that-makes-sense-to-you’ course structure (in which students are guided to formulating principles to account for, say, syntax data). What unites the two investigation-oriented course structures is that, in Pullum’s words, ‘neither could care less what Hjelmslev thought’ (1984:155).

In his discussion of the two approaches, Pullum clearly advocates for investigation-oriented teaching, but he goes on to articulate an opposition view, advanced by Adrian Akmajian, that such a model (which was predominant in the United States at the time) results in students who have a narrow grasp of linguistics as a whole. Pullum goes on to cite a letter from Akmajian (April 14, 1982):

Many linguists in this country complain that linguistics departments don’t train their students in the Cook’s Tours method. These are often ‘linguists’ outside of linguistics departments (e.g. in anthro, foreign languages, education, etc.) who complain that linguistics departments aren’t ‘broad’ enough or that training isn’t ‘applied’ enough, and so on. Even though the majority of well-known linguistics departments in the US … attempt to provide students with sound training, nevertheless we often hear (at least at non-elite non-private schools) the voices of the tour-guides carping at us. (Pullum 1984:155)

In fact, Pullum concludes by articulating a view he thinks Akmajian would have stated: ‘We are still striving toward the elusive right way to teach our subject, and it would be arrogant and foolish to pretend there is a simplistic recipe for the perfect course’, a
maxim that strikes us as particularly valuable in its call for linguists to be reflective (i.e. scholarly) teachers.

At first glance, it might appear that the CARE framework lands us solidly in Pullum’s camp, namely, that the right way to teach phonology and phonetics is within an investigation-oriented course, but we feel that such a characterization of CARE is overly simplistic. In fact, we view the implementation of CARE in the phonetics/phonology classroom as a way to incorporate both views. First, the process of engaging in research makes it clear, experientially, to the students that the things we come to believe about language (phonetics in particular) are answers that are derived through the process of articulating a research question and carrying out a study. Beyond this, although the incorporation of a focused research study is obviously a version of an investigation-based course structure, we feel that, as a result, this frees us to use something of a Cook’s tour method in the remaining portion of the course (though we don’t necessarily discuss Hjelmslev!). More concretely, as an example from the Spring 2019 initiative, we surveyed various approaches to vowel harmony through linguistic history—pre-SPE, SPE, autosegmental phonology, optimality theory, articulatory phonology—thereby providing students with something of a sampling of various linguistic theories and, more importantly, a sense of how linguistics has grappled with a specific question over time. However, because this tour is focused in the sense of using a single phenomenon, and because it is related to the phonetic study being implemented, we feel that this mitigates the drawbacks of the Cook’s tour method Pullum criticizes.

Relatedly, a referee comments that it is difficult to see how sufficient prerequisite material can be covered while also implementing a CARE research project. In our case, as noted above, neither of our courses acts as a prerequisite for any others, so we did not have to worry about addressing specific material. In programs where the natural fit for a CARE project is a class that functions as a prerequisite to others, then it might only be possible to incorporate a much smaller research project, and it may be that in some cases, the restrictions of the major and curricular content make it impossible to incorporate CARE. That said, there is some evidence that prerequisites serve only limited usefulness (Landrum & Gurung 2013), and we encourage our colleagues to consider the role of prerequisites for later courses. For example, while there certainly exists some prerequisite content (e.g. knowing the IPA, or how to analyze a phonological data set), in other cases what is desired is a certain degree of ‘linguistic maturity’. However ill-defined that concept may be, we suggest that participating in authentic research satisfies that goal, and content that is truly prerequisite could be covered in something akin to the Cook’s tour method.

Finally, we turn our attention to present-day concerns in linguistic pedagogy. Although our personal experience is that linguists have long been interested in effective teaching (as demonstrated by the educational debates of the early 1980s that Pullum refers to) and furthermore that linguistics already has a fairly strong tradition of incorporating undergraduates in research, the formal study of linguistic pedagogy is still in

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8 Indeed, we would hesitate to propose that an investigation-oriented approach is always appropriate. On this point, we draw on the recently published *Battle in the mind fields* by Goldsmith and Laks (2019), who, clearly opposed to the sentiment that we ought not care what Hjelmslev thought, argue that:

> once an answer is certified as true and placed among our certainties, we forget the question to which it was the answer, and the consequence is that we forget what were the alternatives that once enjoyed some traction … But this phenomenon leads in a natural way to a sclerosis of the mind, a hardening of the mental arteries, and in the end a less adequate understanding of what the disciplines have learned the hard way. (pp. 1–2)
its infancy. For example, an NSF-sponsored grant for SoTL in linguistics was started in 2019, although SoTL initiatives have existed in other disciplines for some time now. We view the CARE framework as lying within the SoTL goals of articulating and advancing sound pedagogical practices within linguistics. In this vein, we are inspired by pedagogical innovations in recent decades in applied linguistics, in which it is common to find classroom activities based around tasks. Such approaches advocate for a holistic approach to teaching foreign languages in which deep learning takes place, by structuring classroom activities in such a way that students interact with each other in the target language in order to perform some goal-directed task (Willis 1996).

To illustrate with an example of how interacting with the data during a research project leads to a deeper understanding of content, let us consider the case of vowel height. It is rudimentary in any introductory class in phonetics and phonology to address vowel classifications based on height and the front-back axis. This is normally followed up by a plot of first (F1) and second (F2) formants for a specific vowel inventory that supposedly explains why we call /i/ and /u/ ‘high’ vowels and so forth. However, this sound-to-space mapping is still highly abstract and may even seem somewhat metaphorical to students, since the link between F1 and F2 and tongue posture in the vertical and horizontal dimensions of the vocal tract is not immediately obvious.

Consider an alternative. In the combined phonetics and phonology class at UNA V, content related to vowel classifications was first given during a lecture on vowels (in accordance with the textbook). The students were shown the typical scatterplot of the F1 and F2 for Spanish vowels. Not much more was said about vowel classifications at the time, but the students were told that they would appear on a written exam. The students memorized the classifications easily since there are only five vowels in Spanish. However, the fact that the students could memorize them for an exam does not mean that they truly understood the classifications. Nevertheless, once the students began interacting with the ultrasound vowel data for the research project in which the sound-to-space mapping was no longer abstract (since students actually observed the tongue moving across a physical space to reach its articulatory target), they were able to conceptualize the vowel classifications based on their own personal experience and engagement with the data. Many ‘aha!’ moments were observed with regard to vowel classifications over the span of the course at UNA V. Importantly, a deeper understanding of the content was achieved by performing a goal-directed task (segmenting/labeling) that was encapsulated in the broader context of a research project.

5. Assessment. In this section we discuss assessment, both with respect to our students’ work and with respect to the effectiveness of CARE as a pedagogical initiative.

5.1. Assessing students. There is an inherent tension between bringing students into the research process as collaborators and mentees and also assessing their performance as such. Within the SoTL literature there is an abundance of work on assessment, including reconceptualizations such as specifications-based grading (Nilson 2015), which focus on the idea that student grades should reflect student mastery of the material and that students should be given multiple opportunities to demonstrate their mastery; for an example of the application of specifications-based grading in an undergraduate linguistics course, see Zuraw et al. 2019. More radical approaches to student assessment argue that grading is itself counterproductive to learning (e.g. https://ungrading.net/) and that grades should be entirely omitted from student learning. Some motivations underlying the ‘ungrading’ movement are that grades limit risk taking and create a fear of failure, both of which impede real learning. As Schinske and Tanner (2014) note, ‘the evaluative
aspect of grading may distract students from a focus on learning”, and they suggest that providing opportunities for students to earn grades for simply doing the work redirects student focus to learning, engagement, and collaboration.

Because our goal was for students to engage with us as collaborators and to participate authentically in the research process, we did not feel that a strict grading regimen for the research component was appropriate. With respect to the research project, we assessed students in one of three ways, depending on the task; other components of the course, such as problem sets, quizzes, and exams, were graded in more traditional ways. As indicated above, early components of the research, such as completion of the IRB, data collection, and segmentation, were graded as complete/incomplete, but with the added pressure that if deadlines were not respected, students could not pass the research component of the course. We did not provide numerical grades on that component of the research project, but instead provided feedback and guidance; further, we allowed students to redo a component past the due date if honest mistakes were made. We opted for this approach to assessment because we thought it would facilitate a more authentic collaborative relationship, one built upon a mentor-mentee model.

Because we also wanted to ensure that students were being reflective about their learning, we asked that students submit frequent short reflections on the research process, as described in §2.4. These were graded on a three-point scale, and students lost points only if they did not fully answer the reflection prompt; they were assured that, provided they identified strategies for improvement and were constructive in their criticisms, they could not lose points for negative reflections. While we might not have been overjoyed to read student criticisms and complaints, we were pleased to see that our students felt comfortable being upfront about their difficulties with the course and their distaste for various aspects of the research process (segmentation being, unsurprisingly, the biggest complaint).

The final project presented an additional challenge with respect to grading because we explicitly encouraged students in the last portion of the research project to contribute to it based on their strengths and skill sets; this was particularly true at CMU, where some students took it upon themselves to write the bulk of the final papers, while their group members tweaked the analysis scripts and generated tables and graphs. Assessment of the final projects was thus done differently at CMU and UNAV. At UNAV, the class’s final project was to prepare a scientific poster and present the results at a special poster session organized with other faculty members from the Philology Department. Those faculty members were instructed to ask difficult questions and to rate the students’ responses as well as their posters. Evaluating faculty members were given rubrics on which to judge the quality of the posters, and 50% of the grade was determined by the average score on the rubrics; the remaining 50% was administered by the second author. At CMU, students presented PowerPoint presentations to the second author and the UNAV students in a video-conference, and were expected to field questions from both authors. Following the video-conference, we conferred on the students’ performance, and grades were assigned holistically and to the group as a whole. Students also wrote self and peer reviews, and these were consulted to ensure that all group members contributed equally (which they did in the Spring 2019 implementation), in which case they all received the same grade.

Overwhelmingly, the students did an excellent job, and many of the presentations and posters they created could easily be presented with little change at an undergraduate conference. Certainly, the data were not perfect, and we do not pretend that our students
finished our course with an in-depth understanding of the statistical methods used, but overall we feel that the students effectively engaged in authentic research.

5.2. Assessing CARE. Whatever tension might exist in assessing students’ performance as researchers and collaborators, the difficulties are only magnified when we consider the broader question of assessing undergraduate research experiences, since measuring the effectiveness of a pedagogical intervention requires an assessment of how much learning takes place.

UREs and CUREs are often assessed at least in part by student self-reports (see e.g. Myatt 2009, Robertson & Blackler 2006), but as discussed by Linn et al. (2015), these are a poor measure for assessing whether undergraduate research experiences deliver the pedagogical benefits they are claimed to deliver. Nevertheless, we view the results of the self-reports as outlining promising future directions, and an important area of future research is to explicitly test the pedagogical benefits of the CARE framework.

Linn et al. (2015) propose that, in order to assess whether UREs justify the considerable resources required to implement them, assessment should focus on whether students exhibit skills such as improved use of scientific practices, increased ability to interpret original sources, and a better sense of possible flaws in research designs. Part of the issue in assessing whether UREs have pedagogical benefits might be that in some implementations undergraduate students are involved in data analysis (e.g. as lab assistants) but not in the interpretation of results. Because the CARE framework is intended to provide students with experience in as much of the research process as possible, we expect that students who participate in CARE will exhibit increased proficiency in their understanding and implementation of scientific literacy and practice. Future iterations of CARE will incorporate pre- and post-tests to assess students’ development as researchers.

The final survey for the Spring 2019 courses was administered after the research projects and poster presentations had been completed. Students were asked to evaluate their skill-set development and general impressions of their learning. The results across institutions differed, with all of the UNA V students indicating that, given another opportunity, they would like to carry out another research project, while considerably fewer of the CMU students indicated such a desire. We attribute this difference primarily to the difference in student demographics, academic cultures, and workload at the two institutions: for example, several of the graduating seniors at CMU indicated that the experience was inherently valuable, but that they would have appreciated it more if they were not in their final semester and in the throes of ‘senioritis’. Other students at CMU identified various skills that they learned or improved upon (including, for example, communication, organization, and technical skills), but also clearly stated that the experience solidified their view that research was not for them and, for example, crystallized their decision not to apply to graduate school. By contrast, other students not only expressed immense gratitude for the experience, but also stated that, in spite of the monotony of labeling and segmentation (by far the most common complaint), the experience had solidified their decision to continue with research and ultimately with graduate school.

Although all of the students at UNA V expressed trepidation about learning statistics in the pre-project survey, all of them reported in the post-project survey that they wanted to continue learning about statistics in order to do more sophisticated analyses than the t-tests they performed with the ultrasound software (known as Articulate Assistant Advanced software, or AAA). Further, all of the UNA V students agreed that work-
ing on this project significantly enhanced their problem-solving skills. At CMU, both due to the fact that several students came in with some mathematical and technical competency and due to the nature of the statistical models (namely, mixed models) that were specified in the data-analysis scripts, some students expressed regret that this was a skill that was generally blackboxed. These are considerations that we will take with us in designing the next implementation of CARE.

With specific regard to the collaborative nature of the projects, students were generally positive. For example, common responses to the question of what they liked the most were: ‘addressing a common problem in groups’, ‘all the members came together to help each other’, and ‘taking the opinions of others into account and having to negotiate solutions within the team’. This is astonishing given that 94% of the UNA V respondents commented that there was at least one ‘major’ problem their group had to overcome. At CMU, students expressed appreciation for the different skills the group members brought to the table. At various times throughout the semester, some of the students enrolled in humanities majors worried that they would have little to contribute in comparison with the technical competencies of their classmates in STEM majors, but this worry proved unfounded, as various comments in the post-project survey revealed. For example, one student expressed a newfound confidence in their humanities degree, noting that they were able to synthesize the results, write them up, and create a coherent narrative that the rest of the group depended on to create the final presentation. Just as positively, the students in STEM majors expressed the same appreciation for their classmates pursuing humanities degrees, noting in some cases that the work would never have come together if it had not been for the skills these students brought to the table.

6. Conclusion. In sum, the CARE approach is founded on a large body of research that supports the pedagogical value of engaging students with research in a collaborative environment, and its necessary reliance on active learning ensures that students acquire a variety of research-based and transversal skills. Our beliefs about student learning and research—namely, that learning is best nurtured in a community, by counting on the diverse strengths that each group member brings to the table, and by performing a task that is encapsulated in an experience—were supported by our inaugural experience. We hope that the outline of this approach encourages other faculty to incorporate undergraduate research into the laboratory phonology classroom, using the CARE principles outlined herein.

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