

Promoting interest in science through inquiry-based learning in undergraduate linguistics: A case study

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Abstract. In an effort to broaden interest in science, STEM educators advocate for the use of inquiry-based pedagogies. These pedagogies actively engage students in the scientific process, thereby increasing students' scientific literacy, as well as their confidence and interest in science. Although inquiry has been widely implemented in canonical STEM-related fields, students in linguistics, a scientific discipline, can likewise benefit from these approaches. This paper presents a case study of the implementation of inquiry through guided discussion in an undergraduate course in psycholinguistics. Results indicated that students rated the inquiry course as more stimulating/engaging and rated their learning and desire to continue learning as higher.

Keywords. inquiry-based learning; psycholinguistics; guided discussion; science literacy

1. Introduction. Although the field of linguistics often takes a scientific approach to studying the nature of language, most people would not include linguistics in their canonical conception of science. This misconception of the field may present a challenge to linguistics instructors whose students may not come into the classroom recognizing that their scientific knowledge is relevant. One way to deal with this challenge is to implement teaching strategies that encourage science literacy. Inquiry-based pedagogies are one such strategy. Inquiry-based teaching methods are commonly used in the natural sciences (but see, Zachery, 1998 for an example in Psychology). They have been shown to increase students understanding of the scientific method and critical thinking abilities compared to more traditional methods of instruction (e.g., Casem, 2006; Chaplin, 2003; Domin, 1999; Gormally et al., 2009; Howard & Miskowski, 2005; Kogan & Laursen, 2014; Russell & French, 2002; Siritunga et al., 2012). These learning gains are especially large in traditionally underserved student populations (e.g., Amaral, Garrison, & Klentschy, 2002; Eddy & Hogan, 2014; Roseberry, Warren, & Conant, 1992). The goal of this paper is to present evidence that inquiry-based teaching methods can be successfully incorporated into a linguistics course. This paper describes an undergraduate course in psycholinguistics that implements inquiry-based teaching through a guided discussion. Evidence from end of the semester student feedback suggests that this course is successful at helping students develop their intellectual skills such as critical thinking and inquiry, and gain confidence in their ability to effectively discuss and evaluate complex ideas.

The first section of this paper describes some background information on the efficacy of inquiry-based instruction in more traditional STEM fields. The second section describes how inquiry was implemented in an undergraduate psycholinguistics course. The third section describes how the course met the designated learning objectives of the course. The final section discusses the implications of using inquiry-based practices in linguistics education.

2. Background. Inquiry-based learning is a teaching pedagogy that is rooted in the education theory of constructivism and can be traced back to educational theorists such as Dewey (1933).

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Proponents of constructivism posit that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe, and the ideas, events, and activities with which they come in contact (Cannella & Reiff, 1994; Richardson, 1997). Dewey argued that training thought requires that students engage in the act of discovery by experimenting. Instructors who adhere to this philosophy focus on getting students to answer compelling questions and to discover solutions on their own (e.g., Justice et al., 2009; Suchman, 1961) and argue that knowledge is acquired through involvement with content not imitation or repetition (Kroll & LaBoskey, 1996).

The term inquiry-based learning has been applied to a number of different teaching strategies (Spronken-Smith & Walker, 2010). While there is no single way to implement inquiry, there are several commonalities in all of the approaches:

1. Student learning is stimulated by inquiry (i.e., questions or problems).
2. Student learning is based on a process of constructing knowledge and new understanding.
3. Students take an active approach to learning (e.g., learn by doing).
4. The instruction assumes the role of a facilitator.
5. Learning becomes self-directed as student knowledge increases.

There is an ever-growing body of evidence showing that compared to students in traditional lecture-based courses, students in courses that use inquiry-based pedagogical methods show a greater sense of ownership in learning, greater gains in knowledge of course content, greater gains in science literacy, and gains in confidence in their own ability to do science (e.g., Casem, 2006; Chaplin, 2003; Domin, 1999; Gormally et al., 2009; Howard & Miskowski, 2005; Kogan & Laursen, 2014; Russell & French, 2002; Siritunga et al., 2012).

In addition to providing learning gains, inquiry is also a more inclusive form of instruction. There is mounting evidence that traditional, lecture-memory based teaching methods are less (or not at all) effective for students who are traditionally underrepresented in the academy (women, students from minoritized groups, first generation students, lower performing students, and lower income students; Eddy & Hogan, 2014). But high-impact practices, including inquiry, have been shown to be beneficial to many underrepresented groups, while not harming students who are well-served by traditional practices (e.g., Amaral et al., 2002; Eddy & Hogan, 2014; Roseberry et al. 1992). For example, Finley and McNair (2013) found that traditionally underserved students reported deeper learning gains after engaging in high-impact practices. The size of these gains was especially large for first generation and African American students. Further, Kogan and Laursen (2014) found that lower achieving students enrolled in a first year inquiry-based math course received higher grades than students enrolled in a lecture-based course, and the higher grades continued in subsequent math courses. Inquiry-based practices may also encourage persistence in a course of study. Kogan and Laursen found that first year math students who took an inquiry-based course persisted longer in their math studies than students whose first year math course was lecture based. The effect on persistence was greater for women than for men. A possible mechanism for these increases in persistence, especially for traditionally underserved students, may lie in increases in confidence. Siritunga et al. (2012) found that Hispanic undergraduates reported higher confidence in their ability to do science after an inquiry-based botany lab course compared to a traditional “cookbook” style lab. These findings suggest that inquiry-based methods may be one tool for encouraging students from underrepresented populations to persist in scientific areas of study.

Inquiry-based pedagogies have clearly been shown to increase students' science literacy as well as confidence in their own science abilities. Thus, linguistics instructors who are interested in highlighting the scientific nature of the field may benefit from the implementation of inquiry-based strategies. It is not claimed that the approach discussed here is novel—many instructors may incorporate some (if not all) of the strategies discussed here. The goal of this article is to contribute to the discussion about incorporating science literacy into the linguistics classroom and to provide one model for doing so.

3. Intervention. Given that inquiry-based pedagogies have been shown to increase learning for traditionally underserved students, it is unsurprising (but worth noting) that this course has been successfully taught on two campuses with very different student populations. While the second author teaches at a relatively selective, state-related research institution, the first author teaches at a regional campus of a large public research institution. The regional campus focuses solely on undergraduate education and has an open-enrollment policy. Because of the campus' open-enrollment policy, the student body has a higher proportion of non-traditional students than campuses with more restrictive enrollment policies.

The course described here uses a structured approach to implementing inquiry. Although some inquiry-based approaches use an open model, where students guide the discussion through questioning, this approach does not offer proper cognitive support to novice learners (Kirschner, Sweller, & Clark, 2006). In order to provide appropriate cognitive support for the students, the instructors use directed discussion to guide students through the process of inquiry. Prior to coming to class, students are assigned one or two primary source articles to read. The discussion centers on breaking down those articles. The instructors provide discussion questions that allow students to engage in the process of science by thinking and reasoning about the hypotheses, predictions, patterns of data, and data interpretations. The discussion questions follow the NIH's instructional model for promoting active, collaborative, inquiry-based learning (National Institutes of Health, 2005). According to the "5E" instructional model, the Process of Scientific Inquiry is comprised of five broad actions: 1) *Engage*: students participate in the scientific process; 2) *Explore*: students investigate the nature of the problem and begin to construct their knowledge; 3) *Explain*: students connect their previous knowledge to prior learning; 4) *Elaborate*: students apply concepts to new situations; and 5) *Evaluate*: students demonstrate their knowledge by performing their own investigation.

Both the global structure of the course and each class discussion are designed to move students through the stages of the 5E instructional model. There are five major instructional components to the course: class discussions, brief homework assignments, a midterm, a final exam, and a research project. Class discussions (which will be described in more detail below) are structured around providing students opportunities to engage, explore, explain, and elaborate. The research project provides students the opportunity to engage in the scientific process. For this project, students choose a topic within psycholinguistics, complete a literature search, and come to a conclusion about the state of knowledge in the field. The project is scaffolded throughout the semester to help students shape their research question and argument. This assignment engages students in all five of the actions listed in the 5E instructional model. It allows students to *engage* in the scientific process. They independently investigate the nature of the problem and, through their literature search, begin to construct their knowledge (*explore*). They are encouraged to connect what they have already learned in the class to the new information they are learning through their project (*explain*). They apply what they have learned in the course to a new topic (*elaborate*). Finally, they demonstrate their knowledge of how the

scientific process applies in a psycholinguistic setting by designing or performing their own investigation and evaluating its strengths and weaknesses (evaluate). Finally, the midterm and final exam are written exams in which students respond to two or three writing prompts. The midterm and final exam provide students the opportunity to explain and elaborate. The prompts ask students to describe theoretical perspectives and the evidence in support of those perspectives that have been discussed in class (explain). In addition, students may be asked to make predictions about a novel experimental set up based on different theoretical perspectives (elaborate). Finally, students may be asked to propose a hypothesis based on data discussed in class and design a novel experiment to test that hypothesis (elaborate).

Class discussions are structured around deconstructing the article that was assigned. For each discussion, the instructors bring handouts to class to guide the discussion which is used to guide the discussion. Discussions begin with a chance for students to reflect on the topic for the day and how it relates to their own experiences. Some topics, e.g. common ground, are easy for students to relate to their own experiences. But for topics for which relevant phenomena are often not noticed, e.g. disfluencies, students prepare by doing a simple homework to gather and reflect on a few examples of that phenomenon from their personal experiences in the days before the homework is due. For example, during the discussion on disfluencies, students begin by sharing from their homework recent examples of disfluencies they made themselves or heard someone else make. Then they reflect on what situation and circumstances may have led to the disfluency. This part of the discussion allows the students to explore the nature of the problem and begin to connect what they already know about language to the topic at hand.

The discussion then moves to the nature of the questions researchers are asking about the topic. During this part of the discussion, one or two new experiments are introduced and students discuss the hypotheses, the logic of the experimental paradigms, and the results. Then students explain how the data relate to the hypotheses and elaborate on how it all relates to the broader research topic. This leads into a discussion of the paper(s) they read for class. Again, students discuss the hypothesis, predictions, logic of the experimental design, and the results. Finally, near the end of the class period, students are asked to evaluate the data presented in class to come to a conclusion about what is known about the topic and what other questions should be asked.

4. Outcomes. In addition to familiarizing students with the major theories, methods, and findings in the field of psycholinguistics, the course is designed around two main learning outcomes. Namely, in this course students will: 1) develop intellectual skills such as critical thinking and inquiry; and 2) gain confidence in their ability to effectively discuss and evaluate complex ideas. Because the course is structured according to the 5E Process of Scientific Inquiry instructional model, which is designed to promote these learning outcomes based on evidence-based principles, and both instructors explicitly instruct and have designed the course to highlight the Nature of Science (Lederman, 2004), the course should support these learning outcomes. Although this course has not been formally assessed, evidence from end of the semester student feedback is consistent with previous research on the benefits of inquiry and suggests that students in this course are achieving these desired learning outcomes.

The first learning outcome is to help students develop their intellectual abilities, in particular, critical thinking and inquiry. As described above, active forms of learning have been shown to increase these abilities in students, thus, this course uses an active form of learning, namely, guided discussion. On both instructors end of the semester evaluations, students rate the courses as highly stimulating/engaging and rate themselves as learning more compared to other courses. For example, in the most recent section of the first author's course, students rated the

intellectual stimulation of the course a 4.2 on a scale of 1-5 and rated the amount they learned as 4.5 on a scale from 1-5, where 3 is 'average'. Across the two most recent sections of the second author's course, students rated the intellectual stimulation of the course a 4.7 on a scale of 1-5 and rated the amount they learned as 4.4 on a scale from 1-5, where 3 is 'about the same as other courses'. These higher than average ratings are consistent with previous research on inquiry methods showing student rate their learning as higher in inquiry courses compared to more traditional courses (Casem, 2006; Chaplin, 2003; Domin, 1999; Gormally et al., 2009; Howard & Miskowski, 2005; Kogan & Laursen, 2014; Russell & French, 2002; Siritunga et al., 2012). Consistent with evidence that students are more likely to continue in a field of study after an inquiry-based course (Kogan & Laursen, 2014), on the first author's end of semester evaluations, 100% of students answered affirmatively to the question "After taking this course, will you be more likely to try to learn more about the science of language by reading books or articles?" In fact, two students in the course wrote that they wished the campus offered more courses on language. This affirmative response rate is higher than the first author's course in cognition, which uses an active-lecture teaching pedagogy where only 65% of students responded affirmatively that they would continue to learn more about cognitive psychology. Finally, more directly related to the critical thinking learning outcome, on end of the semester feedback, the first author found that 80% of students described the critical thinking skills they gained during the class as the most important thing they learned in the course. This percentage is higher than students in the first author's cognitive psychology course: in that class no students commented on critical thinking skills, instead they described particular concepts as being the most important thing they learned.

The second learning outcome for this course is that students will gain confidence in their ability to effectively discuss and evaluate complex ideas. This requires a decentering of authority which we accomplish using a discussion-based pedagogy in which students are encouraged to ask their own questions. Students are also encouraged to recognize gaps in their knowledge prior to (and during) course discussions and to recognize the contributions their peers make to their learning. Finally, students are given the opportunity to engage in a peer review of drafts of their peers' research projects, which provides a more formal (than in class discussions) opportunity to evaluate complex ideas. Scholars in composition studies have argued that engaging in peer review builds students' confidence in evaluating complex ideas (e.g., Mangelsdorf, 1992). The fact that, anecdotally, both instructors notice an increase across the semester in the number of students who become engaged in the course discussions, also suggests that students gain confidence in their ability to effectively discuss and evaluate complex ideas. After the most recent iteration of the course, the first author asked students on the end of semester evaluations whether the goal of "building confidence discussing complicated topics" was met. All of the students (100%) completing the evaluations agreed that the goal had been met.

5. Conclusions. The goal of this paper is to present evidence that inquiry-based teaching pedagogies, which are common in traditional STEM fields, can be successfully implemented in a linguistics course. The paper presents an undergraduate psycholinguistics course that implements inquiry through guided-discussion. The course utilizes the NIH's '5E' NIH's instructional model for promoting active, collaborative, inquiry-based learning. Students read one or two primary source articles before coming to class. The instructors prepare questions that guide students through the "5E's" of inquiry (engage, explore, explain, elaborate, evaluate). Evidence from student feedback suggests that the course meets its goals of developing students' critical thinking skills and confidence discussing and evaluating complex ideas.

In the United States, public understanding and interest in science is notable low (Funk & Goo, 2015), especially among women and other minoritized groups. One advantage to using inquiry-based pedagogies is they increase students' confidence in their scientific abilities and persistence in science-related fields, and this is especially true for women and students from other minoritized groups (Kogan and Laursen, 2014; Siritunga et al., 2012). In fact, there is evidence that an early inquiry-based intervention can increase long-term attitudes toward science and interest in science careers (Gibson & Chase, 2002). In college and university settings, there are large gender disparities between the number of men and women choosing specific college majors: Women are more likely to choose humanities and the social sciences, while men tend toward engineering, math, and physical sciences (Aud et al., 2010). Linguistics, perhaps because of its non-canonical science status, attracts more women than men (LSA, 2018). Linguistics courses, then, offer an opportunity to engage with individuals who are not necessarily interested in or comfortable around science, precisely the students who benefit the most from inquiry-based pedagogies (Amaral et al., 2002; Eddy & Hogan, 2014; Roseberry et al., 1992). Interest in language could become a bridge into science for girls (and women). The recognition that language can be studied scientifically may increase their interest in science more broadly. Thus, using teaching methods that increase confidence in science abilities in linguistics courses may broaden participation in science.

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