

The Role of Language in Shaping Students' Understanding of Fundamental Electrical Engineering Concepts

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Introduction

This poster is drawn from a larger NSF CAREER award (DRL 2237543) focused on investigating how language shapes students' conceptual understanding of fundamental electrical engineering concepts. Previous research has identified the critical role language plays in learning environments since it is through language that we develop shared meaning. However, in engineering, little is known about how language helps instructors and students convey ideas, explain concepts, and create a mutual sense of meaning, which is essential to understanding complex engineering concepts. Through the use of simple vocabulary and clear explanations, instructors can transform abstract and technical knowledge into practical and understandable concepts.

In the first phase of this work, we developed a classroom observation called Language Observation Protocol in Engineering Classrooms (LOPEC). This protocol was designed to capture the three variables associated with the register construct of Systemic Functional Linguistics (SFL) framework: field, tenor, and mode. To achieve this, the behaviors observed by the protocol are divided into four categories: Students are Doing, Instructor is Doing, Instructor Communication, and Student-Teacher Interaction. We then tested the protocol in various engineering classes and collected data from two sophomore-level electrical engineering courses.

The purpose of this poster is to present our preliminary findings, which emphasize the critical role of language in fundamental electrical engineering courses. This pilot study was conducted at a predominantly white institution (PWI), and we plan to expand this research to Hispanic-serving institutions (HSIs) and historically Black colleges and universities (HBCUs).

Theoretical Framework

For this study, we utilized the Systemic Functional Linguistics (SFL) framework, a comprehensive linguistic approach that emphasizes how language functions in communication and conveys meaning across diverse social contexts []. Rather than viewing language as a rigid set of rules, SFL considers it a dynamic system of choices individuals make when expressing themselves through speech or writing [1]. SFL examines the application of foundational grammar to establish both

register and meaning and is organized around three main constructs: foundational grammar, register, and meaning. Specifically, it analyzes the components of register: field, tenor, and mode; as well as the components of meaning: ideational, interpersonal, and textual—while observing their interaction [2].

For this study, we focused on the construct of register, which refers to the context in which language is used. Register is shaped by three key variables that influence effective language use: field, tenor, and mode [3]. Field relates to the subject matter or topic of communication, including the specialized vocabulary, knowledge, and concepts required for effective discourse. Tenor addresses the relationship between the speaker and the audience, as well as the tone or mood of the communication. It considers the intended audience and the way the message is delivered, which significantly impacts language and style choices. Mode refers to the medium and channel of communication, focusing on how the message is conveyed, whether through spoken or written language, and the associated choices of words, sentence structures, and overall communication style.

Methods

The data for this poster were collected during the fall semester of 2025 at a Predominantly White Institution (PWI) in the U.S. We identified two sophomore-level electrical engineering courses and gathered data through 10 direct classroom observations, 16 descriptive surveys, focus groups with eight students, and semi-structured interviews with the two instructors who taught the courses. All procedures related to the observation protocol, surveys, focus groups, and interviews were approved by the university's Institutional Review Board (IRB).

Results

In this poster, we want to highlight three main results. First, since students in these courses are introduced to new and abstract concepts, instructors need to provide explanations using real-world examples and emphasize the physical meaning of these concepts. For example, one instructor stated:

"When I introduce capacitors, I first explain that it is a device that stores charge. You want to talk about the physical meanings of it. For example, for capacitors, the way we introduce

it is as a device that will store charge. At this point, students don't yet know exactly how it operates and why it stores charge, but that's just a high-level picture that we give the students so they understand."

This is related to the Field construct of SFL, as it pertains to the vocabulary instructors use to engage in effective discourse. Instructors recognize the importance of simplifying this vocabulary and connecting it to students' prior knowledge at the beginning, allowing students to grasp the concept before being introduced to more abstract knowledge. Second, the majority of students believe that solving problems in class with instructors using scaffolding techniques significantly aids their understanding of concepts. However, a small number of students believed that this technique only helped them solve problems for exams, without deepening their conceptual understanding. One student noted:

"I believe it did help me understand how to solve the problem, but conceptually, I still struggled to understand why it worked. I believe that just solving the problem alone is usually not enough for me to be able to replicate it in an exam setting, for example, as understanding why something works tends to be how I can retain the knowledge needed."

This relates to the Mode construct, as it refers to the medium instructors use to explain concepts, particularly through scaffolding problem-solving. This method is commonly used in electrical engineering courses; however, its effectiveness remains debated. While it helps students learn to solve problems, it may not necessarily help in long-term conceptual knowledge retention. Third, instructors do not consider it essential to understand the demographic background of their students because they believe the concepts they are teaching are fundamental and must be delivered in a standardized manner. An instructor remarked, "Their backgrounds have little to do with what I need to deliver. There are other courses following this one that require certain knowledge to be introduced here, so we have to do it." This relates to the Tenor construct, as it does not take the intended audience into account. Instructors believe that the language used to explain fundamental electrical concepts cannot be adjusted based on the audience receiving the knowledge.

Discussion and Conclusion

This poster highlights the complex decisions instructors face when introducing abstract concepts in fundamental electrical engineering courses. They must carefully choose effective teaching methods, determine how to communicate concepts, and address students' learning needs. As demonstrated in the results, using the SFL lens emphasizes the critical role of language in these courses. These findings shed light on the ongoing challenges of teaching abstract, technical concepts and will inform future studies by highlighting areas where the role of language can enhance instructional approaches to better support diverse student populations.

References

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