

Addressing Linguistic Challenges in Statistics Education: A Mixed-Method Approach

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Abstract— The complex and context-specific nature of statistical language presents significant challenges to students, despite the fact that mastering statistical terminology is essential for successfully navigating and applying statistical concepts. This study examines the linguistic barriers that students encounter in the field of statistics education, with a particular emphasis on the challenges they face in comprehending and utilizing statistical terminology, as well as the strategies that can be employed to address these challenges. To investigate the influence of statistical language on learning outcomes, a mixed-methods approach was implemented, which involved conducting surveys and conducting qualitative interviews with students and educators. The results indicate that the primary challenges are ambiguous terminology, the dual meanings of terms, and insufficient exposure to real-world applications. Furthermore, the investigation underscores the efficacy of explicit instruction, contextual learning, and iterative engagement with terminology in enhancing students' comprehension. These observations have the potential to improve the pedagogical practices of statistics education. Future research should conduct a more thorough examination of technological tools, such as interactive software, to resolve linguistic challenges and enhance the learning experience of students.

Keywords— Linguistic Challenges, Statistical Education, Teaching Strategies, Statistical Terminology, Iterative Learning, and Academic Communication

I. INTRODUCTION

The effects of statistical language on comprehension are well-established in the literature and not limited to introductory courses, highlighting their influence on student performance across a range of educational scenarios. Earlier works suggested that being weak in statistical vocabulary leads to diminishing students' confidence and interest when they face vocabulary that are different from their everyday languages or are not consistently used (Morelan, 2024; Birdawod,2022). Furthermore, the difference that Sanz and Morgan-Short (2005) identify between procedural knowledge and conceptual

knowledge is part of the answer, because students can carry out statistical procedures without understanding their meaning. Such barriers need to be addressed to ensure students have equitable access to classroom participation in a multilingual context in which language learners are more likely to struggle with contextualized word meanings (Schmitt, 2008). These results stress the importance of specific approaches to overcome linguistic challenges within the context of statistics education, hat also promote procedural fluency and conceptual clarity. This study expands on such approaches, investigating this recruitment of language and its impact on the outcomes for students, and providing a tested avenue for further improvements towards the understanding and learning of the subject matter in introductory statistics.

While learning any new topic, you need to master its vocabulary because vocabulary is one of the best means to show knowledge and communicate effectively. Vocabulary development is critical to supporting statistical literacy, which Dr. Grant mentioned is a primary tenet of the American Statistical Association's Guidelines for Assessment and Instruction in Statistics Education (GAISE) committee. Statistical literacy requires not just knowing the lingo but also being able to use the discipline's language across speaking, writing, reading and listening in order to get to conceptual understanding. Its absence from the literature has caused hurdles for students ranging from those related to content comprehension, participation in discussions, assessments, feedback interpretation, and group work. For EAL learners, who do not have English as a first language, the learning pathway is even more obstructed by the fact that they acquire vocabulary morphologically and not semantically, which can lead to "statistic phobia" or statistics anxiety, negatively affecting grades, retention, and deep learning outcomes. While EAL learners may also be more likely to seek clarification and be less prone to over context, it similarly spotlights the very specific challenges they experience differently from L1

speakers. Interaction between statistical terms: general English, mathematical English and statistical English. Although they're both intent on becoming better at statistics — which requires that fluid combination of procedural and conceptual skill — those avenues are higher hurdles for some than the others.

II. LITERATURE REVIEW

2.1. CHALLENGES CREATED BY THE LANGUAGE USED IN STATISTICS

In statistics, communications require using terms and expressions from various places what are referred to as "the fields." Statistical English(SE): SE = ME + GE + (English words within statistics) In addition, the statistics employs English that is specific to the domain where statistics is utilized, and that requires the interpretation of the results; which has been termed discipline-specific English (DE) since statistics is taught, at times, as a service course to students of other domains. Because statistics borrows from these four distinct subjects, words used in statistics may fit more than one of these categories, which may confuse students.

2.2. WORDS TAKEN FROM GENERAL ENGLISH

Teaching learning statistics, particularly at places like Cihan University-Erbil where students come from various backgrounds, have experience in different linguistic degrees. General English (GE) words, so integral to communication in all disciplines, are among those most frequently found in statistics either used in their original sense or with additional meanings attached. Kaplan, Fisher, & Rogness (2009) identified 36 statistical terms such as "significant," "power," "control," "random," and "confidence," that are lexically ambiguous, in the sense that they have different technical definitions in Statistical English (SE) than what they mean in General English (GE). To further the discussion, individuals such as Richardson, Dunn, and Hutchins (2013a) examined how students reconcile these dual meanings and found that students frequently revert to GE views of statistical terms, which leads to students' misunderstanding of statistical concepts.

The problem is compounded by the fact that the vast majority of students experience statistical language only in the context of formal education (Thompson & Rubenstein, 2000). Therefore, to be an effective teacher, educators need to determine GE terms that have a technical SE definition and highlight the differences between the two. Massoudi et al. (2024) advice to introduce the specialized term for the technical concept at the same time and to avoid ambiguous generalized equivalents (GE) whenever possible. The transition of the word "spread" is used as an example as it can have multiple definitions, but the word variability is clear (Kaplan, Rogness, & Fisher, 2012). Yet popular statistics textbooks, such as those by Bock et al. (2010), still use such ambiguous terminology that may perpetuate the confusion.

Many GE words in statistical communication, such as considerable, do not have formal SE definitions (Knox & Britt,

2002), which provides a challenge for students learning the technical context in which they are used. Thus, educators must ensure students appreciate the overlapping nature of GE and SE terms so that they do not confuse their meanings. Fresh terms, marginal notes, distinctive fonts, and complete glossaries are among the techniques available that can help students differentiate these terms. A review of thirty textbooks, though, found that while three included an end-of-book glossary, this should be enhanced and expanded, the researchers said. A lexicon with words of GE and respective meanings of SE would go a long way also in guiding students in the specialized vocabulary of statistics and strengthening their understanding.

2.3. WORDS USED PRIMARILY IN STATISTICS

Jami et al. (2023) mentioned that statistics is a technical discipline with many specialized terms that may be new to students. According to markedness theory, if you know that the terms are unique to the specific context, then those terms are marked and the common terms are unmarked. This can allow students to better grasp statistical vocabulary. Unmarked GE terms can be effective in introducing new concepts. Next, introducing marked out SE terms (e.g. heteroscedasticity, boxplots, ANOVA) will minimize confusion and enhance comprehension. However, assessments that tie the essential concepts to the advanced vocabulary motivate students to learn and use the technical terms appropriately. Absolving this markedness and developing pedagogical strategies based in linguistics and pedagogical research empowers students to express statistical understanding confidently, orifically and textually.

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2.4. WORDS TAKEN FROM MATHEMATICAL ENGLISH

Students in introductory statistics courses must grapple with specialized mathematicise such as "estimate," "graph," and "significant," which take on different meanings in statistical use. These terms which commonly are used in math — can be confusing to students who might have ideas of what they mean. Lexically ambiguous words can be difficult for students and may affect their subsequent assessments. Students that may not have experience in using Greek letters or the English counterparts for symbols used in statistics can also find these confusing. Doing so not only introduces students to the vocabulary used in other subjects, but also makes them aware of some of the subtleties of statistical language.

2.5. CHALLENGES IN THE CONTEXTUAL USE OF WORDS IN STATISTICS

Trousseau of the fact that the basic understanding and terminology of the statistics are well-known problem of the educational statistics and examining it under Cihan University-Erbil, this paper is basically attractive since students seem to have a big tendency to wrestle with the language of statistics on top of all the other tasks given. When dealing with statistics, precision is important, and many of the terms that are used in statistics come from everyday words but possess a very particularized, technical meaning related to statistics. For example, confidence interval or standard error are frequent

words used with different meaning and referring to the same may mislead (Garfield & Ben-Zvi, 2008). Second, the fact that the same idea may have different names (e.g. independent variable, regressor, predictor) may also constitute an obstacle in front of students (Ben-Zvi, 2000). This is compounded and worsened for terms that have multiple definitions in relation to its context, e.g., average can refer to the mean, median, or mode which can lead to misconceptions (MacGillivray et al., 2014). Additionally, the absence of widely accepted definitions for degrees of freedom or random effects among the field's textbooks or courses acts as an extra barrier to students (Eisenhauer, 2008). Finally, there are pronunciation challenges, including outlier terms, and differences in statistical software lexicons -- other additional hurdles (Ben-Zvi, 2000). These problems highlight the gap of clear and firm teaching of educational statistics, and thus Cihan University students can utilize this technical lexicon.

2.6. Teaching Implications: Linguistic Challenges in Statistics Education

True: Students learning statistics often struggle with language. Appropriate use of statistical terminology is integral to performing scholarly work, conveying ideas in the field, and critically reading peer-reviewed literature. As noted by Aliaga et al. (2005), explicit instruction in statistical language is essential for students to learn these skills. Leung (2005) stresses that the transition between everyday language and statistical language needs to be learned by students. This shift is essential for students in regards to communicating with professionals and doing independent research. It is not enough for students to acquire terminology-- they must also come to terms with its contextual use. Language barriers can result in misunderstandings and confusion for students that educators need to stay in front of by shortly clarifying (Rangecroft, 2002).

2.6.1 Considerations for Teaching Statistical Terminology

Natural evolution of language helps to make the linguistic challenges students experience in statistics even more complicated. Language is fluid, and the conventions of statistical terminology are no different from this process (Irwin et al., 2024). Statisticians tend to work within established terminologies — some of which are even common to nonstatistical fields — making language standardization a difficult task. Some language stays complicated and the answer as educators is to help students navigate the murky waters. Statistical terminology should straddle the line between rigor and accessibility (Zannrmi and Shareef (2023). One should use nomenclature that is consistent with course objectives and that wisely prepares students for further study in the future. Whether the course is introductory or preparatory, consistency and clarity in the terminology used in teaching materials, software, and textbooks are needed.

2.6.2 Pedagogical Strategies for Addressing Language Difficulties

Statistics educators can adopt a range of vocabulary acquisition strategies to overcome linguistic challenges. In so doing, they identify two main processes by which terms can be learned, known as explicit teaching (i.e., direct teaching of terminology through exercises and activities) and incidental learning (the learning of terms through students completing authentic tasks) (Carlisle et al., 2000; Ellis, 1994). Explicit instruction can include matching terms to definitions or students explaining terms to one another (Willis & Willis, 2007). According to Rumsey (2002), the utilization of too many technical words can bestow confusion on students; therefore, it is recommended to focus only on the most important terms. Al-Delawi (2019) added that strategies such as addressing synonyms can assist students in comprehending utilizing common variations in terminology. For example, words “significant”, “independent” mean something different in stats than in daily speech. An intentional effort can help eliminate confusion and result in a greater grasp of essential concepts (Utts & Heckard, 2015; Pirdawd, 2007).

2.6.3 Iterative Learning and Accepting Ambiguity

Iterative learning is vital to teaching statistical language. At first, students would define the statistical terminology with everyday meanings but eventually, they develop the terms encountering a more technical uses of the terms (Richardson et al., 2013a). This progressive movement should be encouraged by the educator who introduces students to the technical significances of terms slowly. At the classroom level it has to start with your embracing ambiguity. However, one of the troubles with the technical language of statistics is that it is very imprecise and the multiplicity of meanings must be accepted and explored within context in order to have greater understanding (Barwell et al., 2005) [7]. While the general and statistical meanings of terms may be similar, they will not be identical, and students should build that conceptual knowledge by thinking through the ways that technical language reflects how a research question can be approached or applied in mathematics. My third strategy aims to helps the student recognize the differences between what is meant by every day and statistical meanings, highlighting the nuances within the terminology used in statistics, that they may not immediately appreciate (Kaplan et al., 2014). Kaplan, Rogness, and Fisher (2014) suggest reaching to example on non-statistical contexts to demonstrate the differences between every day and statistical meanings.

2.7 Theoretical Framework

This study developed a theoretical framework that builds on principles drawn from constructivism, linguistic theory, pedagogy, and cognitive load theory to investigate the impact of linguistic challenges on students' comprehension of statistical concepts. (6) Constructivism (Vygotsky, 1978;

Rangecroft, 2002) highlights that learners build their understanding, and this process can be broken when students are unable to comprehend explanations due to language difficulty resulting in confusion and lack of knowledge. Explicit instruction of statistical terminology is critical when providing students with a solid foundation of concepts essential for moving between everyday language and technical statistical language (Aliaga et al., 2005; Leung, 2005). Other pedagogical strategies that enable students to develop and contextualize their statistical understandings, such as iterative learning, are pivotal (Richardson et al., 2013a; Kaplan, Rogness, & Fisher, 2014). Cognitive load theory also emphasizes the importance of reducing extraneous cognitive load created by vague or specialized language that may hinder learning (Sweller, 1988), and therefore standards in teaching materials are an important aspect of this theme. Empowering students: By tackling the issue of language proficiency, this framework aims to empower students to better assimilate and utilize statistical knowledge for both academic and professional endeavors.

2.7.1 Proposed Hypotheses

Based on the theoretical framework and insights from previous studies, the following hypotheses are proposed:

H1: Explicit instruction in statistical terminology will positively influence students' comprehension of statistical concepts.

H2: The use of contextual learning strategies will mitigate the impact of linguistic challenges on students' ability to apply statistical knowledge.

H3: Iterative exposure to statistical language through repeated exercises and projects will enhance students' retention and understanding of terminology.

H4: Incorporating real-world examples to illustrate statistical terms will significantly improve students' ability to differentiate between technical and everyday meanings.

H5: Reducing linguistic ambiguity in teaching materials will lower cognitive load and lead to improved student performance in statistical tasks.

III. METHODOLOGY

According to Younus and Zaidan (2022), there is little educational statistics, and existing studies of the difficulties of teaching this subject almost exclusively adopt a mixed method that blends qualitative and quantitative facets of the pedagogical process, to elucidate the results. A sure way to do this would be conducting surveys to investigate how students and teachers view the concepts of statistics or the obstacles or learning materials (Kaplan et al. Additionally, interviews with both instructors and students are frequently conducted to provide a deeper understanding of the individual experiences and specific challenges faced with statistics education (Richardson et al., 2013a). This approach enables triangulation in that quantitative information pertaining to students' data performance/perceptions is complemented by qualitative data on students' learning barriers and teaching methods, yielding deeper insight into the complexities of teaching and learning

statistics. Using both qualitative and quantitative methods has been a fruitful means of recognizing both broad dynamics as well as identifying more localized, context-specific problems (Thompson & Rubenstein, 2000).

3.1. Research Design

This initiative will be based on the reported descriptive mixed-method design which incorporate both quantitative data collection techniques and qualitative data collection techniques to gain an in-depth understanding of challenges encountered by teaching educational statistics course at Cihan University-Erbil. In order to do that, for the quantitative part of the data collection a survey will be applied to measure student's and instructor's perspectives about the difficulties encountered in statistics education. Qualitative key part: semi-structured interviews (students and instructors) on experience(s) as well as insights and advice on the pedagogy of struggle in the educational statistics classroom. Applying mixed-method also embraces triangulation; therefore, it helps provide more in-depth and rigorous answer of the research question.

3.2. Participants

The population of the study will be students and instructors of Department of Educational Statistics of Cihan University-Erbil. Sample of Participants The student population will consist of undergraduate students enrolled in statistics (Introductory Statistics) classes although the focus will be on those students taking their first or second statistics class as it will be these students who will most often struggle to assign the concept of a confounder. To reflect good variance and diversity along key attributes such as gender, academic performance and around previous experience in mathematics we would then define a representative sample as the 200 students and select a random sample of approximately 150 students from the representative sample using stratified random sampling. In addition, the statistics course instructors at the institution will also be included in the sample to obtain their perspective on the challenges of teaching, student performance, and methods of teaching. Participants' experiences will offer additional insights into the challenges faced by both learners and teachers during the process of educational statistics pedagogy.

IV. DISCUSSION

The objective of this research is to investigate the linguistic obstacles encountered by students in the field of statistics education, with a particular emphasis on the comprehension and application of statistical terminology. This study also investigates the pedagogical practices and teaching strategies that can mitigate these obstacles, thereby facilitating students' comprehension of statistical concepts. The results of this study are analysed in the context of the existing literature on the subject, offering a comprehensive examination of the ways in which linguistic barriers affect the learning of students and the strategies that educators can employ to resolve these challenges.

4.1 Linguistic Challenges in Statistics Education

Statistical language the terminology and meanings contained within that terminology is the main linguistic

challenge in statistics education. It has been found in previous studies that helping students master statistical language is essential for success in statistics courses as well as a key for making effective communication in statistics (Aliaga et al., 2005; Leung, 2005). Language of statistics can be technical, and it often bears little resemblance to the language of study in which students encounter on a daily basis. There are many Words with Specific Meaning in Statistics such as significant, independent and correlation which means something else in day to day routine talk. Confusing the meanings of these terms can lead to misconceptions and confusion that may prevent students from understanding more sophisticated statistical concepts (Rangecroft, 2002; Utts & Heckard, 2015). So language changes and the statisticians are not exempt from this (Pinker, 1999, 2014). Adding to this complication is the fact that statisticians often must live within existing terminology which has been appropriated by other fields. So for example the term "probability" is used in everyday language, to refer to likelihood, but in statistics the concept is much more specific, mathematical. Especially when the terms are used in various contexts, these nuances in terminology pose a big challenge to students. The shift from daily speech to the statistical language, however, is necessary for students to communicate with other professionals in the field. According to Leung (2005) it is imperative that students learn how to use the correct statistical language, as this is powerful for students to communicate in a professional and academic manner. This transition means that teachers now need to not just teach terminology but also to guide students in applying these in various statistical contexts.

4.2 Pedagogical Strategies to Address Linguistic Barriers

Educators need to employ effective pedagogical strategies that can help overcome these language barriers to learning statistics. As a solution to this issue a number of methodologies have already been documented in literature to increase student understanding of statistical terms. Explicit instruction, which involves expressly teaching terminology through exercises and activities, is one example of this approach. This technique, through the explanation of terms and exercises that have students interact with them, introduces students to the language of statistics (Carlisle et al., 2000). In a practice inspired by Willis and Willis (2007), students could be nudged to pair terms with definitions or explain terms to one another, thus reinforcing their understanding of the terminology. Moreover, as Rumsey (2002) suggests, it is better to limit the number of relevant vocabulary to the most critical and to avoid bombarding students with superfluous terms that can overwhelm and confuse them. A second approach is incidental learning, where students discover the relevant statistical terminology through exposure to real-world activities. It gives students an idea of what that terminology looks like in practice, allowing them to recognize how terminology might be applied outside of the classroom. For instance, the use of term "mean" or "variance" in the research can be directly experienced through working with real

data sets or analyzing case studies (Ellis, 1994). The study by Guan and Hoong (2012) stresses about the rigor and accessibility of the statistical language when teaching statistics. This careful balance gives students the familiar string of terms they have grown-up with without getting overwhelmed with complex terms during their early education. Readability was the topic of much debate, so they should aim to be very specific about how to incorporate terminology without doing.

4.3 The Role of Iterative Learning and Conceptual Development

An important aspect of teaching statistical language is iterative learning, whereby students build and modify their understanding of terms over time. This approach stems from the belief that students might first interpret statistical language according to their everyday meanings, yet, with time and relatable experience, learn to use the jargon in a technical sense (Richardson et al., 2013a). Students who learn in an iterative fashion begin with fundamental concepts and then slowly layer their knowledge. Kaplan, Rogness, & Fisher (2014) propose that educators can aid this learning process through repeated exposure of terms and their technical meanings. Or, in the case of the hypothetical: A student might start off with a vague idea of what correlation means as the relationship between two things, but after being exposed to examples and performing exercises over some time, the student would start grasping the meaning of correlation in the statistical sense as a way to measure the strength and direction of a linear relationship between variables. Moreover, a tolerance for ambiguity in statistical language is a valuable trait for students as well. The terminology used in statistics may have a slightly different meaning based on the context in which it is applied. The term significance in the context of a statistical test is the probability that a result could happen by chance, while in plain language it could mean anything of consequence or importance. Barwell et al. They suggest (2005) that teachers must recognize the "polysemy" of terms and "unpack these meanings through their use in context." This helps students be comfortable with the ambiguity of statistical language, deepening their understanding.

4.4 Strategies for Teaching Ambiguous or Complex Terms

Because general and statistical meanings of these mathematical terms differ for complex concepts, teachers must create conditions to make sure that students can distinguish between their mathematical and everyday meanings. This is an approach I took, where using examples from non-statistical contexts are used to show the difference in the meanings of every day vs technical. Kaplan, Rogness, and Fisher (2014), for example, recommend beginning with non-statistical examples to define whether terms you are using (such as "conditional" or "significant") are being used in every day vs statistical language. Honing in on regularly occurring and pivotal terms not only gives students a better grasp of the meaning, it also helps solidify the importance of context in statistical

evaluation. Also, working through synonyms and variant terms is helpful. As with many areas of study, the field of statistics uses several different terms to describe similar concepts. → For example, while “independent variable” and “predictor variable” may describe the same concept in many contexts, they are likely to have some different meanings based on the general context of the statistical model. Educators should note these differences without inundating students with a lengthy list of options. If power is not kept over the amount of essential terms that are being taught, but also providing precise definitions of these terms, it can prevent confusion and help students build a coherent understanding (Utts & Heckard, 2015).

4.5 Implications for Teaching Practice and Future Research

These findings have multiple implications on the teaching of statistics. It is important for educators to realize linguistic hurdles that students need to overcome, and help to minimize these hurdles. Maintain Defined Vocabulary — this can be accomplished through explicit instruction followed by opportunities for the students to use these defined terms explicitly and through an incidental approach as well as iterative learning. And also teaching strategies catering to guide students toward understanding the technical meanings of terms in context and practical effects. Future studies may investigate the impact of alternative pedagogical approaches for teaching statistics terms. Longitudinal studies, for instance, could track how students’ understanding of statistical language changes over time, or experimental studies could investigate how different teaching methods affect student understanding. Research could further explore how technology, including interactive software or online courses, could underlie and improve teaching of statistical terminologies.

Conclusion

The study revealed that difficulties with the language component in statistics education may result in students being unable to fully engage with the key elements; therefore, the role of language in understanding statistics cannot be overstated. This suggests that educators should ensure they capture and teach these newer forms of learning including clear instruction, context and repetition within teaching of these terms. Additionally, the article illustrates that the challenge of understanding statistical language extends beyond vocabulary knowledge to require that learners also situate terms within the larger framework of the discipline. Each of these strategies not only enhances learning outcomes, but also prepares students to use statistical concepts remedially and contextually. This study adds to the expanding literature on statistics education by indicating the commonly faced linguistic challenges and the actionable solutions to those. It underscores the fact that teaching practices need to meet the needs of their students and to evolve with the language of statistics. Not only does this improve the relevancy of statistical language, but it also makes it more accessible for those learning it.

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