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English for Physics Laboratory Work: Needs Analysis of Undergraduate Learners

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ABSTRACT

The increasing use of English in laboratory manuals requires Physics Education students to possess adequate language skills in order to carry out practical activities effectively. However, many students still struggle to understand scientific terminology and interpret instructions written in English. Previous studies have also shown a gap between the linguistic demands of laboratory work and students' actual language proficiency, making needs analysis essential to conduct. This study aims to identify the English language needs of Physics Education students and the linguistic challenges they encounter during laboratory practice. A descriptive survey method was employed through a mixed-method approach involving fifty students at UIN Syarif Hidayatullah Jakarta. Data were collected using an ESP-based questionnaire and semi-structured interviews, then analyzed through descriptive statistics and thematic analysis. The findings indicate that reading is the most needed skill (M = 4.1; 78%), followed by listening (M = 3.9; 75%), speaking (M = 3.8; 72%), and writing (M = 3.7; 70%). Limited mastery of scientific vocabulary emerged as the main obstacle in understanding texts and instructions. Practically, this study contributes by highlighting ESP needs that are specific to the physics laboratory context, which differ from those addressed in general ESP instruction. These findings emphasize the importance of ESP teaching that focuses on technical vocabulary development, comprehension of procedural texts, and listening practices relevant to real laboratory situations.

INTISARI

Meningkatnya penggunaan bahasa Inggris dalam buku panduan laboratorium menuntut mahasiswa Pendidikan Fisika memiliki kemampuan bahasa yang memadai agar dapat melaksanakan kegiatan praktikum dengan baik. Namun, banyak mahasiswa masih mengalami kesulitan dalam memahami terminologi ilmiah dan menafsirkan instruksi berbahasa Inggris. Studi sebelumnya juga menunjukkan adanya kesenjangan antara tuntutan bahasa di laboratorium dan kemampuan bahasa mahasiswa, sehingga analisis kebutuhan menjadi penting dilakukan. Penelitian ini bertujuan untuk mengidentifikasi kebutuhan bahasa Inggris mahasiswa Pendidikan Fisika serta hambatan linguistik yang mereka hadapi selama praktikum. Metode survei deskriptif digunakan melalui

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pendekatan mixed-method dengan melibatkan lima puluh mahasiswa di UIN Syarif Hidayatullah Jakarta. Data diperoleh melalui kuesioner berbasis ESP dan wawancara semi-terstruktur, kemudian dianalisis menggunakan statistik deskriptif dan analisis tematik. Hasil penelitian menunjukkan bahwa keterampilan membaca menjadi kebutuhan tertinggi (M = 4.1; 78%), diikuti menyimak (M = 3.9; 75%), berbicara (M = 3.8; 72%), dan menulis (M = 3.7; 70%). Penguasaan kosakata ilmiah menjadi kendala utama dalam memahami teks dan instruksi. Secara praktis, penelitian ini memberikan kontribusi dengan menyoroti kebutuhan ESP yang bersifat khusus pada konteks laboratorium fisika, yang berbeda dari pengajaran ESP umum. Temuan ini menegaskan pentingnya pengajaran yang berfokus pada kosakata teknis, pemahaman prosedur, serta latihan menyimak yang relevan dengan situasi laboratorium nyata.

A. Introduction

English for Specific Purposes (ESP) has evolved into a broader and more adaptable field that emphasizes language instruction aligned with the academic, professional, and situational needs of learners. ESP focuses on the vocabulary, topics, and communicative tasks that students encounter in real contexts, supported by materials intentionally designed to meet their specific purposes [1]. This alignment strengthens the relevance of English instruction and enables students to communicate effectively across academic and professional environments [2].

In physics education, English proficiency is essential as it significantly affects students' learning outcomes [3]. This highlights the importance of language skills for understanding scientific concepts and engaging effectively with laboratory materials. As a result, both general English competence and subject-specific language skills are necessary to support the conceptual and practical aspects of physics learning [4].

Research on ESP in science-related fields identifies recurring challenges that students face in laboratory settings. The most frequently reported issue is limited mastery of scientific and technical vocabulary, which affects students' ability to read laboratory manuals, understand safety instructions, and interpret procedural texts written in English [5]. Many laboratory terms appear only in specialized materials and are rarely addressed in standard English courses, causing students to struggle when encountering them during experiments [6]. In addition to vocabulary gaps, previous studies have noted the scarcity of ESP materials specifically tailored to laboratory procedures, resulting in instructional content that does not fully address students' actual academic needs [7]. Needs analysis research by Sulistio [8], identified significant gaps between the language demands of physics laboratory contexts and the English instruction typically provided to students. This discrepancy highlights the necessity for more context-specific ESP materials.

These linguistic challenges extend to practical laboratory activities. Students often find it difficult to understand spoken instructions, laboratory announcements, and experiment videos, especially when these are delivered in English with unfamiliar accents [9]. During experimental activities, students also encounter difficulties in understanding technical expressions related to equipment operation, calibration

procedures, units of measurement, and data interpretation, as scientific and technical information is predominantly presented in English and requires adequate mastery of technical English proficiency [10]. As a result, students frequently depend on peers for translation or clarification, a practice that increases the likelihood of misunderstandings or procedural errors [8].

The limitations in vocabulary and procedural comprehension also affect students' communicative competence when presenting experimental findings. Needs analysis studies have identified that students require targeted support in describing experimental observations, explaining results, and participating in scientific discussions in English [5]. Literature reviews in ESP, such as that conducted by Sintia et al. [6], consistently identify vocabulary limitations as a major barrier affecting students' fluency and clarity in scientific communication. These issues collectively demonstrate the need for ESP instruction that is contextualized to laboratory-specific language demands.

The theoretical basis of this study is grounded in the broader ESP framework, which scholars describe as encompassing English for academic, occupational, vocational, or general practical purposes depending on learners' goals [11]. Rahman [12] classifies ESP into two main divisions, English for Academic Purposes (EAP) and English for Occupational Purposes (EOP), each serving distinct communicative functions relevant to students and professionals in scientific fields. Within this classification, English for Science and Technology (EST) provides the most appropriate lens for understanding the linguistic needs of physics laboratory learners.

The present study employs the theoretical model of Dudley-Evans and St John, as discussed in Yan [13], to frame the investigation. This model consists of three interrelated components: (1) needs analysis, which identifies the specific linguistic and communicative requirements of laboratory tasks; (2) course design, which aligns ESP instruction with authentic laboratory procedures, materials, and communication genres; and (3) ESP practitioner roles, which emphasize the teacher's responsibility in integrating scientific content with language instruction so that learners acquire both conceptual understanding and laboratory-appropriate communication skills.

The physics laboratory serves as a central context in this study due to its established role in supporting students' conceptual understanding and inquiry processes through hands-on experimental activities. Laboratory environments provide opportunities for active experimentation, data collection, and analysis, which enhance students' comprehension of scientific concepts and support the development of scientific reasoning and self-efficacy in science learning [14]. Through hands-on activities, students develop inquiry skills, problem-solving strategies, and the ability to articulate scientific processes, all of which depend on clear communication and comprehension of relevant terminology [15]. Laboratory work also encourages interaction, peer learning, and the articulation of scientific conceptions, making language a critical component of successful engagement in experimental tasks [16].

Based on this background, the present study is designed to (1) identify the English language needs of students when conducting physics laboratory activities and (2) examine the linguistic and procedural difficulties they encounter when using English in laboratory settings. By addressing these aims, the study seeks to provide a more detailed understanding of learners' communication challenges and contribute to the development of ESP instruction that is more contextual, relevant, and responsive to the realities of physics laboratory practice.

B. Method

This study employed a descriptive survey design with a mixed-methods approach to comprehensively understand students' needs regarding English language use during physics laboratory activities. In such a design, quantitative data serve as the primary data, used to map general patterns of students' needs, while qualitative data support them by providing deeper explanations and contextual insights. This position concurs with Creswell & Clark [17], who detail that, in an explanatory or convergent mixed-method design, quantitative data provide an overview of the phenomenon, while qualitative data supplement and illustrate the results through more detailed contextual information.

Fifty students from the Physics Education Study Program at UIN Syarif Hidayatullah Jakarta participated in this study and were purposively selected based on their experience of attending laboratory practicum courses. Three students were chosen as interview participants for qualitative data collection, which is considered sufficient because small-scale qualitative studies typically reach data saturation with two to three participants, a condition in which the information becomes repetitive, and no new themes emerge.

The research instrument was a five-point Likert-scale questionnaire to measure the levels of need, difficulty, and frequency of use of four English language skills: Reading, listening, speaking, and writing. Each of these was operationally defined as the skills to understand procedural texts, diagrams, and tables; follow verbal instructions and understand videos of English experiments; explain experimental steps and discuss physics concepts in English; and write laboratory reports on the characteristics of tools and procedures using appropriate scientific terms. The questionnaire's reliability test, using Cronbach's Alpha, yielded 0.97, indicating very high internal consistency. Examples of the items of the questionnaire are as follows: "I can understand procedural instructions in the laboratory manual," "I am able to follow verbal explanations during practicum sessions," "I can explain experimental steps in English," and "I can write descriptions of tools and materials using scientific terminology."

Semi-structured interviews were conducted as part of the qualitative data collection to gain deeper insights into the reasons, experiences, and difficulties students face when using English during laboratory activities. The interviews were

conducted online with the participants' consent, recorded, transcribed, and analyzed by using thematic analysis: coding, categorizing themes, and interpreting them. All procedures followed principles of ethical research, including informing participants of the purpose of the research study, their right to refuse or withdraw from the research interview at any time, and the guarantee that all data would be anonymous and used only for academic purposes.

Quantitative data were analyzed by descriptive statistics to retrieve mean scores and patterns of need for each language skill, while qualitative data were analyzed to enhance the interpretation of quantitative findings. Triangulation was conducted methodologically through the comparison of the two types of data to enhance the accuracy and comprehensiveness of research results.

C. Results and Discussion

This section presents the findings of the study in relation to its main objectives, namely to identify the English language needs of physics students during laboratory activities and to examine the linguistic difficulties they encounter in that context. The results are organized into quantitative data derived from the questionnaire and qualitative insights from the interviews. Together, these findings provide a comprehensive overview of how students engage with English in laboratory settings and the specific language skills required to support their learning.

Table 1. Reading Skills Needed for Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Understanding procedural steps	4.2-4.4	78-82%	High
Interpreting diagrams	3.8-4.0	71-76%	Medium
Reading scientific articles	<3.8	<71%	Low

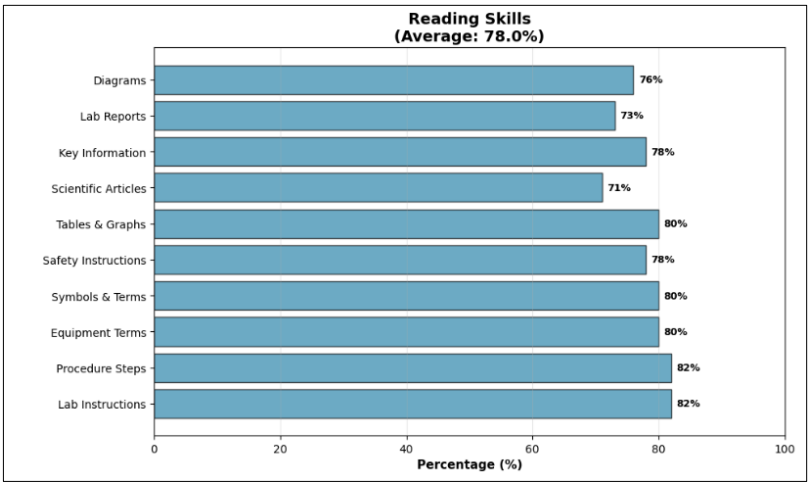

Figure 1. Reading Skills

Reading skills were identified as the most needed aspect. Most respondents stated that they often encounter laboratory manuals, experimental procedures, and scientific texts written in English. The ability to comprehend English texts is considered essential for students to conduct experiments accurately and correctly.

Table 2. Writing Skills Needed for Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Writing conclusions	3.9-4.2	73-78%	High
Scientific vocabulary	3.6-3.7	67-71%	Medium
Error analysis	<3.6	<67%	Low

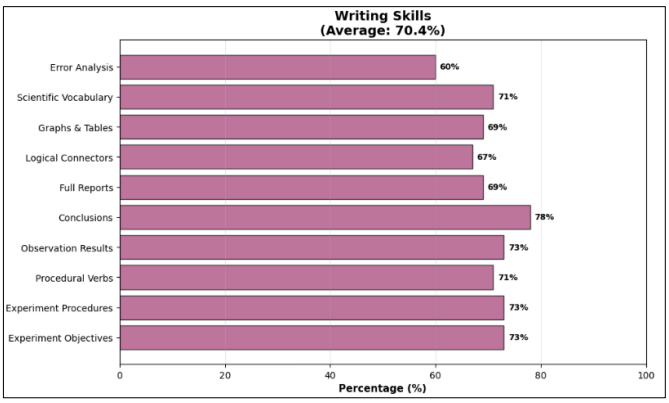

Figure 2. Writing Skills

Writing skills were also viewed as important, especially for composing laboratory reports. However, some respondents expressed difficulty in selecting appropriate scientific vocabulary and using correct grammar when writing.

Table 3. Speaking Skills Required in Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Explaining experimental steps	3.8-4.3	73-80%	High
Presenting hypotheses	3.5-3.7	67-71%	Medium
-	<3.5	<67%	Low

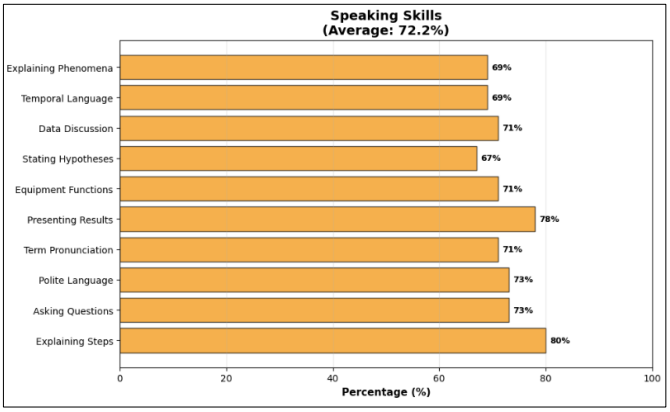

Figure 3. Speaking Skills

Students reported that they rarely use spoken English in the laboratory, except during presentations or group discussions. Nevertheless, some students mentioned that speaking skills could be useful for future academic presentations or international collaboration.

Table 4. Listening Skills Required in Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Understanding lecturer's instructions	3.9-4.4	75-82%	High
Following instructor's directions	3.4-3.8	64-73%	Medium
-	<3.4	<64%	Low

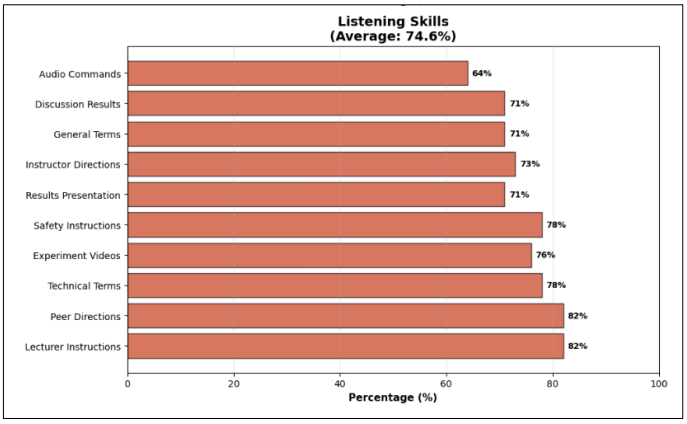

Figure 4. Listening Skills

Students stated that the ability to understand oral instructions from lecturers or laboratory assistants is important. Difficulties in comprehending spoken explanations often lead to confusion during the implementation of experiments.

Table 5. Summary of English Language Needs Across Four Language Skills

Most Critical Skill	Average Score	Need Level	Language Skill
Understanding Procedures	4.1	78%	Reading
Lecturer's Instructions	3.9	75%	Listening
Explaining Procedures	3.8	72%	Speaking
Writing Conclusions	3.7	70%	Writing

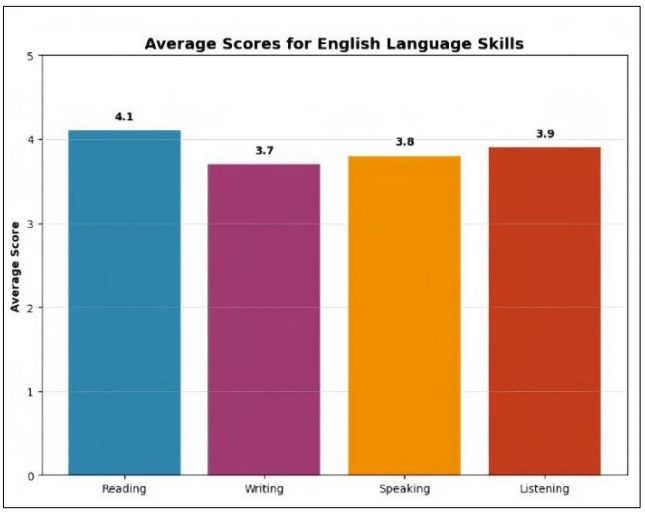

Figure 5. Average Score for English Language Skills

The analysis of the questionnaire administered to fifty Physics Education students showed that reading had the highest mean score (M = 4.1), followed by listening (M = 3.9), speaking (M = 3.8), and writing (M = 3.7). Reading emerged as the most essential skill because students rely heavily on written materials such as laboratory manuals, procedural texts, equipment descriptions, and safety guidelines. These materials form the foundation of every laboratory activity and must be understood before students can carry out any experimental procedures. Listening needs were also notably high, particularly because students must follow instructors' oral explanations and real-time safety instructions during laboratory work. In contrast, speaking and writing received lower ratings because these skills are required only at specific stages, such as presenting results or writing conclusions, and are less central to the immediate operation of laboratory activities.

These patterns align with the nature of physics laboratory practices, which place stronger demands on receptive skills. Unlike classroom-based ESP activities that frequently involve discussions, presentations, or writing assignments, laboratory environments require students to comprehend protocols, interpret diagrams, read procedural steps, and follow verbal guidance in real time. Each experiment begins with reading instructions and continues with listening to clarifications from lecturers or laboratory assistants, making the ability to understand written and oral input far more essential than the ability to produce extended scientific language. This highlights that laboratory contexts shape a distinctive ESP profile characterized by procedural literacy and immediate comprehension demands.

To refine the descriptive findings, score variability was examined through standard deviations. The standard deviations for the four skills were relatively low (SD $\approx$ 0.25–0.32), indicating that student responses were consistent and that the

perceived needs were largely shared across the cohort. Reading and listening showed the least variability, reinforcing the strong consensus that these skills are most crucial in laboratory work. Meanwhile, speaking and writing showed slightly higher variability, reflecting differences in prior exposure, confidence levels, and familiarity with productive tasks.

Further analysis based on student characteristics revealed additional patterns. Students in later semesters reported slightly higher reading and listening needs than those in earlier semesters, likely due to increased engagement with more complex laboratory procedures. Students with lower GPAs or limited English course experience assigned lower scores to items involving technical vocabulary, indicating greater difficulty interpreting scientific terminology. Similarly, students who had not taken science-oriented English courses reported lower confidence in writing methodological sections of laboratory reports. These variations show that ESP needs in laboratory settings are not homogeneous but shaped by academic exposure, linguistic background, and the extent of laboratory experience.

Table 6. Summary of Interview Data on Students' Difficulties and Needs

Respondent	Skill	Difficulties and Needs
Respondent 1	Reading	Difficulties: "The vocabulary." Needs: "Getting used to using physics terms in English."
	Writing	Difficulties: "Having difficulty writing the description of tools or materials in English." Needs: "Getting used to using physics terms in English."
	Speaking	Difficulties: "Having difficulty explaining experimental steps in English." Needs: "Getting used to using physics terms in English during practice."
	Listening	Difficulties: "Never watched an English experiment video." Needs: "Getting used to listening to physics terms in English."
Respondent 2	Reading	Difficulties: "Understanding experimental procedures without visual aids." Needs: "Practice reading academic physics texts with visual supports (graphs and tables)."
	Writing	Difficulties: "Writing the method section of lab reports." Needs: "Guidance in writing scientific reports focusing on grammar and method structure."
	Speaking	Difficulties: "Not fluent in discussing physics concepts in English." Needs: "Practice in academic speaking and pronunciation of physics terminology."

Respondent	Skill	Difficulties and Needs
Respondent 3	Listening	Difficulties: “Understanding English experiment videos, especially with British accents.” Needs: “Listening practice using lab-related videos with various accents to improve comprehension.”
	Reading	Difficulties: “Hard to understand lab terms & physics vocabulary.” Needs: “Practice reading & lab vocabulary.”
	Writing	Difficulties: “Hard to write theory & explain graphs.” Needs: “Guidance for lab reports & writing practice.”
	Speaking	Difficulties: “Cannot explain procedures & concepts.” Needs: “Speaking practice & simple presentations”
	Listening	Difficulties: “Hard to understand accents & lab instructions.” Needs: “Exposure to lab videos & listening practice

The qualitative findings reinforce and contextualize the quantitative patterns obtained from the questionnaire. The survey results indicated that limited mastery of scientific vocabulary is the primary obstacle across reading, listening, speaking, and writing, a finding confirmed by Respondent 1, who emphasized that their most significant difficulty lies in understanding vocabulary across all skills. This consistency demonstrates that scientific terminology serves as a fundamental barrier to comprehension during laboratory activities.

Furthermore, the questionnaire showed that students struggle to understand procedural instructions and English-language experiment videos, a finding supported by Respondent 2, who explained that interpreting procedural texts without visual support is a significant challenge, particularly when listening to experiment videos delivered with unfamiliar accents. The alignment between the survey data and this statement confirms that listening demands are exceptionally high in laboratory contexts because students must process information in real time.

The questionnaire also revealed that productive skills, especially speaking and writing, received lower scores because students find it difficult to use technical terminology when constructing scientific explanations. This result aligns with the statement of Respondent 3, who reported difficulties in verbally explaining concepts and writing tool descriptions due to limited mastery of technical vocabulary. These findings indicate that the primary barrier to productive skills is not grammar but an insufficient command of scientific lexical items.

Overall, the interview evidence is consistent with the questionnaire data. This triangulation clarifies that vocabulary mastery is not merely a component of a single language skill but a foundational factor that simultaneously influences reading, listening, speaking, and writing. The lack of lexical resources leads students to

struggle with decoding instructions, interpreting procedural texts, following oral explanations, and articulating scientific ideas accurately. This is the main reason receptive skills rank highest: students depend on their ability to understand written and spoken input before they can produce language effectively.

These findings align with the theory of English for Specific Purposes (ESP), which emphasizes the importance of needs analysis in designing language instruction relevant to the academic context [12]. In addition, these results support the studies of Sintia et al. [6] and Mourssi [9], which state that the lack of mastery of scientific vocabulary and the limited exposure to English in scientific practice are the main causes of students' low ESP proficiency. Thus, both the quantitative and qualitative results show a consistent direction, namely that students need more contextual ESP instruction, especially in strengthening scientific vocabulary, understanding procedural texts, and developing listening skills based on the physics laboratory context.

Beyond describing students' needs, the present study offers a significant contribution and novelty to ESP research. Unlike previous studies that generally examine program-level or classroom-based ESP requirements, this study demonstrates a clear novelty that laboratory-based ESP presents a distinct needs profile characterized by strong demands for procedural literacy, real-time oral comprehension, and discipline-specific vocabulary. It also specifically focuses on English language needs withing physics laboratory which remains as underexplored area in ESP. Additionally, the study reveals the integration of linguistic and procedural dimension that vocabulary limitations function as a cross-skill bottleneck affecting the four language skills simultaneously and directly influence students' accuracy in conducting experiment. This is a nuanced insight that has received limited attention in prior research. These findings highlight the urgency of developing ESP materials that are explicitly integrated with laboratory practices rather than relying solely on general academic English. Such an approach would better support students' safety, accuracy, and performance during experimental activities.

D. Conclusion

The present study shows that students' English language needs in physics laboratory contexts are closely shaped by the procedural and real-time nature of experimental work. These characteristics create a stronger demand for reading and listening skills compared to speaking and writing. The results also indicate that scientific vocabulary serves as a cross-skill challenge that simultaneously affects comprehension and language production. This research offers a fresh contribution to the field of ESP by illustrating that laboratory-based ESP possesses a unique needs profile, defined by procedural literacy, discipline-specific terminology, and real-time oral comprehension, which differs from the typical requirements found in classroom-

based ESP. Such findings provide a more context-sensitive understanding of how language functions within authentic scientific practices.

Building on these findings, several practical recommendations can be made. ESP instruction should incorporate laboratory procedures directly into its learning materials, focusing on the mastery of scientific vocabulary, the interpretation of procedural texts, and listening exercises that replicate actual experimental conditions. Moreover, productive language activities, such as presenting experimental results or writing laboratory reports, should include explicit vocabulary support to help students overcome specific lexical difficulties. Curriculum developers are also encouraged to work collaboratively with laboratory instructors to ensure that language teaching aligns closely with the real workflows and communicative practices of laboratory environments.

While this study provides valuable insights, it also has several limitations. The research was conducted within a single institution, which may limit the generalizability of the results. Furthermore, the quantitative data were based on self-reported perceptions, which may not fully reflect students' actual language performance during laboratory tasks. Future studies should therefore employ performance-based assessments, compare findings across multiple institutions, and examine how ESP programs grounded in laboratory practices influence students' safety, accuracy, and communicative effectiveness during experiments.

In conclusion, this study underscores the importance of developing ESP instruction that is deeply integrated with laboratory activities, offering both practical implications and theoretical contributions to the broader field of English for Specific Purposes.

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