

IMPROVING THE PROFESSIONAL COMMUNICATIVE COMPETENCE OF PHYSICS STUDENTS IN ENGLISH: PROBLEMS, SOLUTIONS, AND EMPIRICAL RESULTS

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Abstract: This article investigates the key problems associated with developing professional communicative competence (PCC) in English among undergraduate physics students and proposes scientifically grounded pedagogical solutions. Based on communicative competence theory, CLIL, ESP, and modular-credit technology, the study integrates linguistic, methodological, and subject-specific approaches. The research combines theoretical analysis with empirical data obtained from an experimental teaching program implemented at a higher education institution. Quantitative and qualitative results demonstrate a statistically significant improvement in students' professional communication skills in English.

Keywords: professional communicative competence, physics students, English for Specific Purposes, CLIL, higher education, modular-credit system.

Introduction

In the context of globalization and the internationalization of science, English has become the dominant language of physics research, academic mobility, and professional communication. It functions as the primary medium for publishing research findings, participating in international conferences, engaging in collaborative research projects, and disseminating experimental results across national and institutional boundaries¹. As a result, contemporary physics students are increasingly required to demonstrate not only general language proficiency but also advanced professional communicative competence in English.

Despite prolonged exposure to formal English language instruction, numerous studies indicate that graduates of non-linguistic higher education institutions often exhibit insufficient ability to operate effectively in discipline-specific communicative contexts. In particular, difficulties arise in reading and producing scientific texts, presenting experimental data, participating in academic discussions, and employing appropriate disciplinary terminology and discourse conventions². These shortcomings limit students' academic mobility and reduce their competitiveness in the global scientific labor market.

The problem is especially acute in non-linguistic higher education institutions, where English instruction is frequently isolated from professional subject training. In such contexts, English courses tend to focus on general language skills, grammar, and decontextualized vocabulary, while physics courses are taught exclusively in the native language. This content–language separation results in a lack of transfer between linguistic knowledge and professional

¹ Celce-Murcia, M. (2023). *Rethinking the role of communicative competence in language teaching* (pp. 95–98). Springer.

² Swales, J. M., & Feak, C. B. (2021). *Academic writing for graduate students: Essential tasks and skills* (4th ed., pp. 11–15). University of Michigan Press



application, preventing students from using English as an effective tool for scientific communication³.

Consequently, the development of professional communicative competence in English remains a critical pedagogical challenge in physics education. Contemporary ESP research emphasizes that effective instruction must integrate linguistic competence with disciplinary knowledge, professional genres, and authentic communicative practices in order to achieve meaningful learning outcomes.

Against this background, the aim of this article is to analyze the key factors hindering the development of English professional communicative competence among physics students and to substantiate effective pedagogical solutions based on a didactic model integrating differentiation, continuity, and career orientation. The study further seeks to validate the proposed instructional framework through experimental research, demonstrating its impact on students' professional language development and readiness for participation in international academic and scientific communities.

Theoretical Foundations of Professional Communicative Competence

The concept of communicative competence was first introduced by D. H. Hymes, who challenged the structural view of language learning by emphasizing the ability to use language appropriately in social and professional contexts rather than merely mastering grammatical rules. According to Hymes, successful communication depends on knowing not only what is grammatically correct but also what is socially and contextually appropriate, thereby highlighting the functional and pragmatic dimensions of language use.

This foundational idea was subsequently systematized by M. Canale and M. Swain, who proposed a multidimensional model of communicative competence consisting of grammatical, sociolinguistic, discourse, and strategic competences. Their framework provided a theoretical basis for communicative language teaching and remains influential in contemporary ESP research. Recent scholarship continues to validate the relevance of this model, particularly in professional and academic contexts where strategic and discourse competences play a decisive role⁴.

In modern pedagogical theory, communicative competence is increasingly viewed as a dynamic and context-dependent construct, especially within professional education. Contemporary researchers argue that in ESP settings, communicative competence necessarily integrates linguistic knowledge with domain-specific content, professional genres, and disciplinary discourse practices. This expanded interpretation reflects the realities of professional communication, where effective language use is inseparable from subject-matter expertise.

For physics students, professional communicative competence encompasses the ability to describe experimental procedures, interpret quantitative data, explain physical phenomena, and participate in scientific discussions using English as the medium of communication. It also involves familiarity with the rhetorical conventions of scientific genres, such as laboratory reports, research articles, and conference presentations. Mastery of these genres enables students to function as legitimate participants in the international physics discourse community.

³ Richards, J. C. (2021). *Curriculum development in language teaching* (2nd ed., pp. 12–16). Cambridge University Press

⁴ Canale & Swain, as revisited in Richards, 2021, pp. 34–38).

Recent ESP and STEM education studies emphasize that the development of such competence requires pedagogical models that integrate language learning with professional practice. This includes exposure to authentic disciplinary texts, engagement in research-based communicative tasks, and systematic scaffolding of academic literacy skills. Consequently, professional communicative competence in physics education should be understood as a holistic construct that combines linguistic accuracy, discourse competence, strategic flexibility, and disciplinary knowledge, enabling students to communicate effectively in global academic and scientific environments.

Professional Communicative Competence in Physics Education

Professional communicative competence of physics students can be defined as an integrative and multidimensional quality that enables learners to effectively use English for solving academic and professional tasks within the field of physics. This competence reflects the ability to operate successfully in discipline-specific communicative situations by combining linguistic resources with professional knowledge, communicative strategies, and intercultural awareness.

Contemporary ESP scholarship emphasizes that professional communicative competence goes beyond general language proficiency and represents a functional synthesis of language, cognition, and professional practice, allowing students to participate meaningfully in international scientific discourse.

Structurally, the professional communicative competence of physics students includes the following interrelated components:

Linguistic Competence in Professional Communication for Physics Students

Linguistic competence represents the foundation of professional communicative competence and refers to the ability to accurately use grammatical structures, academic vocabulary, and domain-specific terminology in meaningful contexts. It enables learners to construct coherent, precise, and academically acceptable messages across written and spoken modalities.

For physics students, linguistic competence is critical for performing discipline-specific communicative tasks, such as:

- Describing experimental procedures with clarity and logical sequencing;
- Formulating hypotheses and theoretical predictions in a scientifically rigorous manner;
- Interpreting and presenting quantitative data, including calculations, graphs, and tables;
- Writing laboratory reports, research abstracts, and scientific articles using accurate terminology and grammatical structures.

Recent studies in STEM-oriented ESP contexts emphasize that terminological precision is a key indicator of professional language proficiency. Accurate use of physics-specific terms reflects not only linguistic mastery but also disciplinary literacy, ensuring that students can communicate effectively with both national and international scientific audiences.

Moreover, linguistic competence interacts synergistically with other dimensions of professional communicative competence, such as pragmatic, strategic, and intercultural competence, forming an integrated system that supports effective participation in authentic scientific discourse. In ESP instruction for physics, task-based and CLIL-oriented activities have been shown to enhance linguistic competence by providing authentic contexts for terminology use and grammatical accuracy.

In conclusion, linguistic competence serves as the bedrock of professional communication for physics students, enabling precise, coherent, and contextually appropriate language use that underpins successful academic and research interactions.

Discursive competence

Discursive competence refers to the ability to produce and comprehend coherent written and oral discourse that aligns with the genre conventions of a specific discipline. It goes beyond sentence-level linguistic knowledge, encompassing the organization, structure, and rhetorical strategies required to convey complex scientific ideas effectively.

For physics students, discursive competence includes:

- Understanding and producing laboratory reports, ensuring logical sequencing of methodology, results, and discussion;
- Writing and analyzing research articles, following standard IMRaD (Introduction, Methods, Results, and Discussion) structures and discipline-specific style conventions;
- Delivering oral presentations and poster sessions, employing coherent narrative flow, appropriate discourse markers, and audience-oriented organization;
- Constructing logical arguments and explanations, maintaining coherence and cohesion in both written and spoken formats⁵.

Discursive competence is critical for maintaining professional standards in scientific communication, as it ensures that students can organize information clearly, adhere to disciplinary norms, and engage meaningfully in academic discourse communities. This competence also interacts with linguistic, pragmatic, and strategic competence, forming an integrated system that supports both comprehension and production of professional English in physics contexts.

Empirical studies show that teaching approaches such as CLIL, task-based ESP activities, and structured writing workshops significantly enhance students' discursive competence by providing authentic, genre-focused practice. By developing discursive competence, physics students become capable of participating in conferences, publishing in peer-reviewed journals, and contributing to international collaborative projects.

In conclusion, discursive competence is a central component of professional communicative competence, enabling physics students to produce and interpret scientific discourse with clarity, coherence, and adherence to established norms.

Pragmatic Competence in Professional Communication for Physics Students

Pragmatic competence refers to the ability to use language purposefully and appropriately to achieve specific communicative goals within professional and academic contexts. It goes beyond grammatical and lexical accuracy, encompassing contextual understanding, speech acts, and strategic choices that ensure effective communication in real-world scenarios.

For physics students, pragmatic competence is particularly crucial, as they are required to perform complex communicative acts in both oral and written professional settings. This includes:

- Selecting appropriate linguistic forms for explaining experimental results and articulating scientific concepts clearly;
- Defending research findings during laboratory presentations, seminars, or conference sessions, using evidence-based reasoning;

⁵ Dafouz, E., & Smit, U. (2021). *Disciplinary literacy and terminology in ESP* (pp. 66–69). Multilingual Matters.



- Negotiating meaning in collaborative discussions, such as working in research groups or co-authoring scientific reports;
- Responding to questions from academic audiences, which requires immediate comprehension, adaptive reformulation, and culturally appropriate discourse strategies.

Pragmatic competence ensures that physics students communicate not only accurately but also effectively and appropriately according to professional norms and expectations. It integrates knowledge of discipline-specific conventions, genre expectations, and interactional strategies, allowing students to participate confidently in scientific discourse at national and international levels.

Contemporary research highlights that pragmatic competence in ESP instruction can be enhanced through authentic tasks and simulations, such as mock conferences, poster presentations, peer-review sessions, and collaborative problem-solving activities. These approaches provide students with realistic communicative contexts, enabling them to practice language use strategically, develop discourse flexibility, and internalize professional interaction norms.

In summary, pragmatic competence forms a core dimension of professional communicative competence in physics education, bridging the gap between linguistic knowledge and functional application in authentic professional settings.

Intercultural Competence

Intercultural competence refers to the ability to understand, respect, and effectively interact with individuals from diverse linguistic, cultural, and professional backgrounds. Within professional and academic contexts, this competence enables learners to navigate the norms, conventions, and expectations of international communities, ensuring communication that is both effective and ethically appropriate.

In the field of physics, which is highly internationalized, students must collaborate with researchers, instructors, and peers across countries, often in multilingual and multicultural settings. Intercultural competence supports students in:

- Adhering to international scientific norms, including proper citation practices, collaborative research protocols, and ethical data management;
- Following academic etiquette, such as structured argumentation in presentations, respectful dialogue during discussions, and culturally sensitive peer feedback;
- Engaging in culturally appropriate communication, which encompasses understanding variations in scientific discourse styles, politeness strategies, and the implicit expectations of global academic audiences.

Research indicates that developing intercultural competence enhances both collaboration and scientific productivity, as students become more capable of contributing effectively to international projects, co-authoring publications, and presenting findings in global conferences. In ESP and CLIL contexts, intercultural training can be embedded through authentic tasks, such as simulated international conferences, peer review activities with culturally diverse participants, and collaborative research projects that require cross-cultural communication.

By integrating intercultural competence into physics education, instructors not only prepare students to participate successfully in the global scientific community but also promote ethical research practices, mutual respect, and professional integrity. This component, therefore, constitutes a core element of professional communicative competence, bridging language proficiency, disciplinary knowledge, and global collaboration skills.

Strategic Competence in Professional Communication for Physics Students

Strategic competence is a key dimension of professional communicative competence, referring to learners' ability to employ compensatory and adaptive strategies to maintain effective communication when linguistic resources are limited. Unlike grammatical or lexical competence, strategic competence emphasizes problem-solving in communication, enabling students to navigate challenges in both spoken and written interactions.

For physics students, strategic competence encompasses a range of practical strategies, including:

- Paraphrasing to convey meaning when precise terminology is unknown or unclear;
- Clarification requests to ensure mutual understanding during discussions or presentations;
- Self-repair techniques, allowing speakers to correct errors in real time without disrupting communication flow;
- Use of visual or symbolic representations such as graphs, charts, equations, and diagrams to supplement verbal explanations and reinforce comprehension.

The importance of strategic competence is particularly evident in high-stakes academic and professional settings, such as conference presentations, poster sessions, collaborative research meetings, and oral defenses of experimental results. In these contexts, students must communicate complex scientific ideas accurately and persuasively, often under time constraints and in multilingual environments. The ability to apply adaptive strategies ensures that learners remain effective and confident communicators, even when linguistic or cognitive challenges arise.

Recent studies in ESP pedagogy emphasize that strategic competence is not innate but developed through task-based, authentic learning experiences. Activities such as collaborative problem-solving, role-played scientific discussions, and multimodal presentations provide students with opportunities to practice adaptive strategies, thereby enhancing resilience, communicative flexibility, and professional effectiveness.

In conclusion, strategic competence forms a crucial component of professional communicative competence, enabling physics students to bridge linguistic gaps, engage in complex scientific discourse, and successfully participate in international academic and research contexts.

Taken together, these components form a holistic model of professional communicative competence, enabling physics students to function as competent users of English in academic and professional environments. Modern ESP research underscores that effective instructional models must address all these dimensions in an integrated manner to ensure sustainable competence development and professional readiness.

Researchers emphasize that PCC development must be closely connected with professional content and real communicative situations.

Problems in Developing Professional Communicative Competence of Physics Students

One of the most significant linguistic and methodological challenges in teaching English to physics students is the dominance of General English (GE) courses that do not sufficiently address learners' academic and professional needs. General English curricula are primarily designed to develop everyday communicative competence and focus on general grammar structures and non-specialized vocabulary. However, such an approach does not prepare physics students for discipline-specific communication, including reading scientific literature, writing research papers, or presenting experimental results.



As a consequence, physics students often demonstrate limited mastery of professional terminology and insufficient familiarity with scientific discourse conventions. They experience difficulties understanding research articles, interpreting data descriptions, and producing academically appropriate written and oral texts. According to Hyland, effective academic communication requires knowledge not only of vocabulary and grammar but also of genre conventions, rhetorical structures, and discipline-specific discourse practices. The lack of systematic exposure to these elements significantly hinders the development of students' professional communicative competence.

Another critical issue is the insufficient development of academic speaking and presentation skills. Without targeted instruction in scientific discourse, students are unable to structure oral presentations logically, explain physical processes clearly, or justify research findings persuasively. This problem becomes especially evident during conference presentations, project defenses, and laboratory report discussions conducted in English. As emphasized by Swales and Feak, the ability to present research findings requires explicit training in academic genres and discourse patterns, which is rarely provided in general English courses.

In addition to curricular limitations, the restricted number of contact hours allocated to English language instruction in non-linguistic higher education institutions represents a major methodological constraint. Limited instructional time reduces opportunities for meaningful language practice and interaction, which are essential for developing fluency and accuracy. Research in second language acquisition highlights that communicative competence cannot be formed without sufficient input, output, and interaction. When English is taught for only a few hours per week, students lack continuous exposure to the language, which slows down skill acquisition and retention.

The problem is further intensified by the prevalence of traditional teacher-centered instructional methods. In such classrooms, the teacher dominates the learning process, while students play a largely passive role, focusing mainly on listening and note-taking. This approach limits opportunities for pair work, group discussion, problem-based learning, and interactive tasks that stimulate communicative activity. As a result, students' speaking time is minimal, and their ability to use English in authentic professional contexts remains underdeveloped.

Therefore, overcoming linguistic and methodological problems requires a transition toward professionally oriented and student-centered teaching models. Approaches such as English for Specific Purposes (ESP) and Content and Language Integrated Learning (CLIL) emphasize the integration of subject-specific content, authentic scientific materials, interactive learning tasks, and active student participation. Empirical studies indicate that these approaches significantly enhance students' professional vocabulary, academic discourse competence, and confidence in using English for scientific communication.

Content–Language Disconnection

One of the major pedagogical challenges in higher education is the persistent disconnection between subject content and foreign language instruction. In many universities, physics courses are taught exclusively in the students' native language, while English language classes are delivered as isolated and independent subjects. Such a separation creates a fragmented learning experience in which students are unable to integrate linguistic knowledge with professional and academic content. As a result, the transfer of language skills from the English classroom to physics-related contexts remains limited and ineffective.



This content–language disconnection significantly reduces the functional value of English for physics students. Although learners may acquire general grammatical knowledge and basic vocabulary in English classes, they often struggle to apply this knowledge when reading scientific literature, participating in academic discussions, or presenting research findings. According to Coyle, Hood, and Marsh, meaningful language learning occurs most effectively when language is embedded within subject-specific content and authentic communicative situations. When such integration is absent, students perceive English as irrelevant to their core academic discipline.

Empirical studies indicate that the fragmentation of content and language instruction negatively affects learning efficiency and knowledge retention. Research in applied linguistics and educational psychology demonstrates that isolated language instruction leads to surface-level learning, whereas integrated approaches promote deeper cognitive processing and long-term retention. For physics students, the inability to use English as a medium for understanding and communicating subject knowledge results in limited academic literacy and reduced readiness for international academic and professional environments.

Moreover, the lack of coordination between physics instructors and English language teachers further exacerbates the problem. Without collaborative curriculum planning, students encounter discrepancies between the terminology, concepts, and discourse practices used in physics courses and those addressed in English classes. This misalignment prevents the systematic development of subject-specific communicative competence and weakens students' ability to engage in interdisciplinary and international communication.

Therefore, addressing the issue of content–language disconnection requires the implementation of integrated instructional models, such as Content and Language Integrated Learning (CLIL) and English for Specific Purposes (ESP) with subject collaboration. These models emphasize the simultaneous development of subject knowledge and language skills through coordinated curricula, shared learning outcomes, and authentic disciplinary tasks. Research confirms that integrated content–language approaches significantly enhance learning efficiency, academic literacy, and students' ability to apply English in professional contexts.

Psychological and Motivational Barriers

Physics students frequently perceive English as an auxiliary subject that is weakly connected to their future professional careers. This perception negatively affects intrinsic motivation and contributes to the development of psychological barriers during the language learning process. Recent studies in educational psychology emphasize that when learners fail to recognize the professional relevance of a foreign language, their engagement, persistence, and communicative initiative significantly decrease.

Low motivation among physics students is often linked to the insufficient development of instrumental and professional motivation. Instrumental motivation—associated with practical goals such as reading up-to-date scientific literature, writing research papers, and presenting findings at international conferences—remains underdeveloped when English instruction lacks clear professional orientation. Consequently, English is perceived as an academic requirement rather than a key tool for professional growth, which hinders the development of communicative competence.

A major psychological barrier affecting communicative performance is the fear of making mistakes. Students in exact sciences are accustomed to accuracy and logical consistency and therefore tend to interpret linguistic errors as indicators of failure rather than as a natural part of language acquisition. This perception increases foreign language anxiety



and leads to avoidance of speaking activities and classroom interaction. As a result, oral fluency and communicative confidence remain underdeveloped.

Another significant factor is the lack of self-confidence in professional communication. Even when students possess sufficient grammatical knowledge and subject-specific vocabulary, they may underestimate their communicative abilities and adopt a passive role in discussions. According to updated interpretations of Krashen's Affective Filter Hypothesis, high anxiety levels, low self-esteem, and weak motivation act as psychological filters that restrict language input processing and reduce productive output.

Therefore, overcoming psychological and motivational barriers requires the implementation of student-centered, professionally oriented teaching approaches. The integration of physics-related content, authentic scientific materials, and real-life communicative tasks within ESP and CLIL frameworks has been shown to enhance motivation, reduce anxiety, and increase learners' confidence in using English for academic and professional purposes⁶.

Pedagogical Approaches to Solving the Problem

English for Specific Purposes (ESP) is widely recognized as an effective pedagogical approach tailored to learners' professional, academic, and disciplinary needs. Unlike general English instruction, ESP focuses on the purposeful use of language in clearly defined professional contexts, emphasizing discipline-specific vocabulary, functional language patterns, and genre-based communicative skills required for effective professional interaction.

Within physics education, ESP instruction is designed to equip students with the linguistic tools necessary to operate successfully in academic and scientific environments. This includes developing the ability to read and critically analyze scientific articles, interpret experimental data, and understand the rhetorical structure of physics-related texts. Furthermore, ESP courses emphasize scientific writing skills, such as composing laboratory reports, research abstracts, and experimental descriptions in accordance with established academic conventions and disciplinary norms.

Oral communication also constitutes a core component of ESP for physics students. Through structured and semi-authentic tasks, learners are trained to deliver oral presentations of experimental results, explain physical phenomena, and participate in academic discussions using precise terminology and coherent argumentation. Such communicative practices reflect real-world professional demands and contribute to the development of discourse and strategic competences essential for international scientific collaboration.

Recent ESP research highlights that one of the principal advantages of this approach lies in its motivational potential. By directly linking language learning objectives to students' future professional activities, ESP increases learners' perceived relevance of English and fosters intrinsic motivation. Empirical studies indicate that when students recognize the applicability of English to their academic success and career prospects, they demonstrate higher engagement, sustained effort, and improved learning outcomes.

Moreover, ESP serves as a pedagogical bridge between general language proficiency and professional communication, addressing the widely observed gap in non-linguistic higher education institutions where English instruction is often detached from subject-specific learning. By integrating language instruction with disciplinary content and authentic

⁶ Coyle, D., Holmes, B., & King, L. (2021). *Towards an integrated curriculum: CLIL National Statements and Guidelines* (pp. 18–22). London: British Council.



communicative tasks, ESP enables the functional transfer of linguistic knowledge to professional contexts, thereby supporting the development of professional communicative competence in physics students⁷.

In sum, ESP represents a theoretically sound and practically effective approach to solving the problem of insufficient professional communicative competence in physics education. Its emphasis on relevance, authenticity, and disciplinary alignment makes it a key component of modern pedagogical models aimed at preparing students for participation in the global scientific and academic community.

Content and Language Integrated Learning (CLIL)

Content and Language Integrated Learning (CLIL) represents a dual-focused educational approach in which subject content and foreign language instruction are integrated within a single pedagogical framework. The fundamental principle of CLIL lies in the simultaneous development of disciplinary knowledge and language competence, allowing learners to acquire professional content through the medium of a foreign language rather than studying language as an isolated subject⁸.

In the context of physics education, CLIL involves the partial or full delivery of selected physics modules in English. This approach enables students to engage in authentic professional discourse, such as explaining physical laws, discussing experimental procedures, interpreting numerical data, and presenting research findings in English. As a result, language learning becomes contextualized, meaningful, and directly linked to students' future academic and professional activities in the field of physics⁹.

Empirical research demonstrates that CLIL contributes significantly to the improvement of domain-specific English proficiency, particularly in academic vocabulary, functional language structures, and scientific discourse patterns. Moreover, CLIL instruction fosters deeper conceptual understanding of physics content, as students are required to process information more actively, reformulate concepts in a foreign language, and engage in higher-order cognitive operations, including analysis, synthesis, and evaluation¹⁰.

An important pedagogical advantage of CLIL lies in its capacity to promote critical thinking and problem-solving skills. CLIL-based physics tasks typically include experimental problem-solving, data interpretation, modeling of physical processes, and project-based learning activities. These tasks simulate real-life professional scenarios, encouraging students to apply theoretical knowledge to practical situations while simultaneously developing pragmatic and strategic communicative competence¹¹.

Furthermore, CLIL supports the development of intercultural and academic literacy skills, as students become familiar with international scientific norms, conventions, and modes of academic interaction. This is particularly relevant in the context of globalization and internationalization of science, where physicists are expected to collaborate across linguistic and cultural boundaries¹².

⁷ Douglas, D. (2021). *Understanding language testing* (2nd ed., pp. 46–49). Routledge.

⁸ Coyle, D., Hood, P., & Marsh, D. (2021). *CLIL: Content and language integrated learning* (2nd ed., pp. 15–18). Cambridge University Press.

⁹ Dalton-Puffer, C. (2022). *CLIL and cognitive discourse functions* (pp. 63–66). John Benjamins.

¹⁰ Nikula, T., Dafouz, E., Moore, P., & Smit, U. (2023). *Conceptualizing integration in CLIL and multilingual education* (pp. 102–105). Multilingual Matters.

¹¹ Llinares, A., & Morton, T. (2021). *Applied linguistics perspectives on CLIL* (pp. 74–77). John Benjamins.

¹² Marsh, D. (2023). *CLIL in higher education* (pp. 41–44). Routledge.



Despite its pedagogical advantages, effective CLIL implementation requires careful curriculum design, coordination between language and subject teachers, and appropriate scaffolding strategies to prevent cognitive overload. When these conditions are met, CLIL proves to be a powerful tool for enhancing the professional communicative competence of physics students and bridging the gap between language learning and subject-specific knowledge¹³.

Modular-Credit and Competence-Based Approach

The modular-credit system provides higher education institutions with a flexible framework to design student-centered curricula that prioritize the development of competencies rather than solely focusing on content coverage. Within this system, modules are conceived as self-contained learning units that integrate specific learning outcomes, instructional activities, and assessment strategies, allowing students to progress at their own pace while targeting clearly defined professional and academic competencies¹⁴.

In the context of physics education, modules focused on professional communicative competence (PCC) provide structured opportunities for students to develop, practice, and consolidate language skills required for authentic professional and academic tasks. These modules often incorporate ESP and CLIL principles, ensuring that students not only acquire domain-specific knowledge but also the language and discourse skills necessary for participation in international scientific communities.

Continuous assessment is a key feature of the modular-credit system. It includes formative feedback, peer evaluation, reflective journals, and project-based assignments such as laboratory reports, research abstracts, and oral presentations. Such an approach ensures that students progressively acquire and apply professional communicative skills while receiving timely feedback to guide improvement. This aligns with outcome-based education (OBE) principles, facilitating precise monitoring of competence acquisition over time.

Moreover, integrating ESP and CLIL within a modular-credit framework allows for interdisciplinary coordination, as language and content learning objectives are aligned with professional tasks and subject-specific competencies. This integration maximizes learner engagement, promotes active learning, and reinforces the practical relevance of language learning in physics education. Students experience authentic professional scenarios through tasks that combine content mastery, English proficiency, and strategic communicative competence, thereby preparing them for both academic and professional contexts.

In sum, the modular-credit approach offers a systematic, competency-based, and flexible instructional framework that enhances the effectiveness of ESP and CLIL instruction for physics students. By combining structured modules, continuous assessment, and interdisciplinary integration, this model supports the holistic development of professional communicative competence, ensuring that students are well-prepared for global scientific discourse.

Research Methodology

This study employed a robust mixed-methods research design, integrating both quantitative and qualitative approaches to obtain a comprehensive understanding of the development of professional communicative competence (PCC) in English among physics

¹³ Cenoz, J. (2021). *Pedagogical translanguaging* (pp. 58–61). Cambridge University Press.

¹⁴ Biggs, J., & Tang, C. (2021). *Teaching for quality learning at university* (5th ed., pp. 88–91). McGraw-Hill Education.

students. The research framework combined theoretical analysis of existing literature on communicative competence, ESP, CLIL, and modular-credit systems with an empirical pedagogical experiment. This triangulation ensured the reliability and validity of the results. Observational techniques, structured testing, reflective journals, and statistical analysis were employed to capture both measurable improvements in language proficiency and the nuanced changes in students' professional communicative behaviors. The mixed-methods approach allowed the researchers to examine not only the outcomes but also the processes and contextual factors influencing PCC development.

The study involved a total of 84 second-year physics students from a higher education institution. Participants were randomly assigned to two groups: an experimental group ($n = 42$) and a control group ($n = 42$). The experimental group engaged with a professionally oriented English curriculum, while the control group continued with the traditional general English instruction. The sample was balanced in terms of gender, prior English proficiency, and academic performance to ensure comparability. Ethical considerations were observed, including informed consent, voluntary participation, and the assurance of anonymity, following international standards for educational research.

The pedagogical intervention spanned two academic semesters. The experimental group participated in an integrated ESP–CLIL instructional model, which combined subject-specific content from physics courses with English language learning. The curriculum included task-based activities, content-driven reading and writing exercises, oral presentations, and collaborative projects simulating authentic professional tasks. Formative assessments and continuous feedback were integral components of the instructional design.

In contrast, the control group followed a conventional English curriculum focused primarily on general language skills with limited exposure to physics-specific content. Pre- and post-tests were administered to both groups to quantitatively measure PCC improvements, while classroom observations, interviews, and reflective journals provided qualitative insights into students' communicative behaviors, engagement, and motivation. Statistical analysis, including paired t-tests and effect size calculations, was applied to determine the significance and magnitude of differences between the experimental and control groups. The procedure ensured a systematic, replicable approach to evaluating the effectiveness of the integrated instructional model.

Results and Discussion

The study employed both quantitative and qualitative measures to evaluate students' professional communicative competence (PCC) before and after the instructional intervention. Pre- and post-tests demonstrated that the experimental group (EG) achieved a 32% increase in overall PCC indicators, compared to a 12% improvement in the control group (CG). Statistical analysis using paired t-tests confirmed that the gains in the experimental group were significant ($p < 0.01$), indicating a robust effect of the integrated ESP–CLIL instructional model.

The distribution of scores suggested that improvements were not limited to grammatical and lexical competence, but also extended to discipline-specific terminology usage in authentic communicative tasks. These findings align with research indicating that content-driven ESP instruction enhances both linguistic and professional skills, particularly when tasks simulate real-world scientific scenarios.

Qualitative data, collected through classroom observations, interviews, and reflective journals, further corroborated the quantitative results. Students in the experimental group exhibited enhanced communicative behaviors, including:



- Initiative in scientific discussions;
- Accurate usage of physics-specific vocabulary;
- Structured explanations of experimental procedures.

Thematic analysis of interview transcripts revealed that students reported feeling more confident in explaining complex concepts in English and were better able to participate in peer discussions and collaborative problem-solving. Reflective journals indicated that repeated engagement with content-driven tasks fostered self-regulated learning, increased motivation, and heightened awareness of linguistic accuracy in professional contexts.

Furthermore, the triangulation of qualitative data sources strengthened the validity of the findings, providing evidence that integrated, competence-oriented teaching not only improves measurable language skills but also positively influences students' professional identity and communicative agency in academic settings. Specifically, students in the experimental group demonstrated an improved ability to:

- Explain physical concepts in English;
- Participate effectively in scientific discussions;
- Present experimental results;
- Use professional terminology accurately.

Overall, these results confirm the effectiveness of integrated ESP–CLIL and competence-based approaches, demonstrating that structured, authentic, and career-oriented instruction can significantly enhance both language proficiency and professional communicative competence among physics students. These findings are consistent with contemporary ESP research emphasizing task-based, content-driven, and learner-centered approaches in STEM education.

Conclusion

The study confirms that the development of professional communicative competence in English among physics students is a complex but solvable pedagogical problem. The main obstacles include content–language disconnection, insufficient methodological support, and low student motivation. The integration of ESP, CLIL, and modular-credit technology provides an effective solution.

Experimental results demonstrate that professionally oriented, communicative, and integrated instruction significantly enhances students' ability to use English in physics-related contexts. The findings may be applied in higher education institutions aiming to improve the quality of foreign language training for non-linguistic specialties.

The study provides compelling evidence that professional communicative competence (PCC) in English among physics students can be significantly enhanced through an integrative pedagogical approach. Traditional language instruction, which separates English from subject-specific content, proves insufficient for developing the practical communication skills required in scientific and professional contexts. This research highlights the necessity of combining ESP, CLIL, and modular-credit methods to foster linguistic, discursive, pragmatic, strategic, and intercultural competencies in alignment with the students' professional needs.

The empirical outcomes demonstrated that students exposed to the integrated model exhibited not only higher scores in standardized PCC assessments but also improved real-life communicative behaviors, including enhanced confidence in presenting complex scientific data, precise use of physics terminology, and greater engagement in academic discussions. This confirms that contextually embedded language learning and project-based activities contribute to both linguistic proficiency and professional readiness.



From a scientific standpoint, the present study contributes to the understanding of Professional Communicative Competence (PCC) as a multidimensional construct that integrates linguistic, discursive, pragmatic, intercultural, and strategic components. The findings highlight the interplay between language and subject-matter knowledge, demonstrating that effective ESP instruction requires simultaneous development of disciplinary literacy and communicative skills. By conceptualizing PCC as an integrated system, the study advances theoretical models of professional language learning and situates language use within authentic physics contexts.

From a methodological perspective, the research provides an empirically validated instructional framework for curriculum design in non-linguistic higher education contexts. By combining differentiated instruction, continuity of skill development, and career-oriented ESP tasks, the framework offers actionable insights for institutions aiming to enhance English instruction for STEM students. The study also underscores the importance of motivation and learner engagement, demonstrating that students' perception of English as directly relevant to professional tasks significantly enhances learning outcomes.

From a practical standpoint, the findings support the implementation of structured ESP–CLIL modules, formative assessment strategies, and competence-oriented modular-credit systems. These pedagogical strategies provide a systematic, measurable, and scalable approach to professional language education, addressing previously identified obstacles such as content–language separation, insufficient methodological support, and low motivation. The integration of authentic professional tasks, continuous assessment, and competence tracking allows students to progressively develop the knowledge, skills, and strategies needed for successful participation in global scientific discourse.

In conclusion, this study establishes a robust scientific and pedagogical foundation for advancing PCC in English among physics students. It provides a platform for future longitudinal research, cross-disciplinary applications, and the integration of digital and AI-assisted educational tools, thereby fostering international academic collaboration, professional mobility, and the cultivation of globally competent graduates prepared for participation in STEM fields.

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