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IMPROVING PHYSICS STUDENTS' PROFESSIONAL COMMUNICATIVE COMPETENCE IN ENGLISH: A DIDACTIC MODEL BASED ON DIFFERENTIATION, CONTINUITY, AND CAREER ORIENTATION

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Abstract. *In the context of the globalization of science and the increasing internationalization of higher education, professional communicative competence in English has become a key requirement for future physicists. The ability to read scientific literature, participate in international research projects, present experimental results, and engage in academic discourse in English is essential for successful professional integration. This study aims to theoretically substantiate and empirically verify a didactic model for improving physics students' professional communicative competence in English based on the principles of differentiation, continuity, and career orientation. The research employs theoretical analysis, pedagogical modeling, and a quasi-experimental design involving control and experimental groups. The findings demonstrate that the integrated implementation of differentiated instruction, continuous competence development, and career-oriented English for Specific Purposes (ESP) instruction significantly enhances students' professional communicative competence. The results contribute to the field of ESP pedagogy and provide practical implications for English language instruction in physics and other STEM disciplines.*

Keywords: *physics education, professional communicative competence, English for Specific Purposes (ESP), differentiation, continuity, career-oriented learning, higher education.*

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Annotatsiya. *Fan globallashuvi va oliy ta’limning tobora xalqaro miqyosda rivojlanishi sharoitida bo‘lajak fiziklar uchun ingliz tilida professional kommunikativ kompetensiyaga ega bo‘lish muhim talabga aylanmoqda. Ilmiy adabiyotlarni o‘qish, xalqaro tadqiqot loyihalarida ishtirok etish, tajriba natijalarini taqdim etish hamda ingliz tilida akademik muloqot olib borish muvaffaqiyatli kasbiy integratsiya uchun zarur hisoblanadi. Ushbu tadqiqot differensiallashtirish, uzluksizlik va kasbiy yo‘naltirilganlik tamoyillariga asoslangan holda fizika talabalarining ingliz tilida professional kommunikativ kompetensiyasini rivojlantirishga qaratilgan didaktik modelni nazariy asoslash va empirik jihatdan tekshirishni maqsad qiladi. Tadqiqotda nazariy tahlil, pedagogik modellashtirish hamda nazorat va tajriba guruhlarini o‘z ichiga olgan kvazi-eksperimental dizayn qo‘llanildi. Natijalar differensiallashtirilgan ta’lim, kompetensiyani uzluksiz rivojlantirish va kasbiy yo‘naltirilgan maxsus maqsadlar uchun ingliz tili (ESP) o‘qitishini integratsiyalashgan holda joriy etish talabalarining professional kommunikativ kompetensiyasini sezilarli darajada oshirishini ko‘rsatdi. Olingan natijalar ESP pedagogikasi sohasiga hissa qo‘shadi hamda fizika va boshqa STEM fanlarida ingliz tilini o‘qitish uchun amaliy tavsiyalar beradi.*

Kalit so‘zlar: *fizika ta’limi; professional kommunikativ kompetensiya; maxsus maqsadlar uchun ingliz tili (ESP); differensiallashtirish; uzluksizlik; kasbiy yo‘naltirilgan ta’lim; oliy ta’lim.*

Аннотация. *В условиях глобализации науки и возрастающей интернационализации высшего образования профессиональная коммуникативная компетентность на английском языке становится ключевым требованием для будущих физиков. Умение читать научную литературу, участвовать в международных исследовательских проектах, представлять экспериментальные результаты и вести академический дискурс на английском языке является необходимым условием успешной*

профессиональной интеграции. Целью данного исследования является теоретическое обоснование и эмпирическая проверка дидактической модели формирования профессиональной коммуникативной компетентности студентов-физиков на английском языке на основе принципов дифференциации, непрерывности и профессиональной ориентации. В работе используются методы теоретического анализа, педагогического моделирования и квазиэкспериментальный дизайн с участием контрольных и экспериментальных групп. Полученные результаты показывают, что интегрированное внедрение дифференцированного обучения, непрерывного развития компетенций и профессионально ориентированного обучения английскому языку для специальных целей (ESP) существенно повышает уровень профессиональной коммуникативной компетентности студентов. Итоги исследования вносят вклад в развитие педагогики ESP и имеют практическое значение для преподавания английского языка в физике и других STEM-дисциплинах.

Ключевые слова: *физическое образование; профессиональная коммуникативная компетентность; английский язык для специальных целей (ESP); дифференциация; непрерывность; профессионально ориентированное обучение; высшее образование.*

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Introduction

The rapid development of science and technology and the globalization of academic communication have significantly increased the role of English as the dominant language of international scientific discourse. For students majoring in physics, English proficiency is no longer an additional skill but a fundamental professional requirement. Scientific publications, international conferences, collaborative research projects, and digital scientific resources predominantly operate in English, making professional communicative competence a crucial component of physicists' professional training.

Despite this demand, English language instruction in non-linguistic higher education institutions often remains insufficiently aligned with students' professional needs. General English courses frequently fail to develop the specific communicative skills required for academic and research-oriented communication in physics. This mismatch highlights the need for pedagogically grounded, profession-oriented approaches to English language teaching.

Recent studies emphasize the effectiveness of integrating didactic principles such as differentiation, continuity, and career orientation into ESP instruction. However, limited research has specifically addressed how these principles can be systematically implemented to improve physics students' professional communicative competence. Therefore, this study seeks to fill this gap by proposing and validating a didactic model tailored to physics education.

The research questions guiding this study are as follows:

1. What constitutes professional communicative competence in the context of physics education?
2. How can the principles of differentiation, continuity, and career orientation be effectively integrated into ESP instruction for physics students?
3. What impact does this integrated approach have on students' professional communicative competence in English?

Professional Communicative Competence in ESP

The concept of communicative competence was first introduced by Hymes[13], who argued that effective language use requires more than grammatical mastery; it involves the ability to communicate appropriately within social and cultural contexts. Canale further developed this concept, proposing a multi-dimensional model comprising grammatical, sociolinguistic, discourse, and strategic

[13] Hymes, D. H. (1972). On communicative competence. In J. B. Pride & J. Holmes (Eds.), Sociolinguistics (pp. 269–293). Penguin.

competences, which laid the foundation for communicative language teaching and assessment. Richards emphasized that these competences are interdependent and must be operationalized in classroom instruction to achieve meaningful learning outcomes.

In the context of English for Specific Purposes (ESP), particularly for physics students, professional communicative competence extends beyond general linguistic proficiency to include domain-specific knowledge, technical terminology, and professional discourse practices. This competence enables learners to interpret scientific texts, describe experimental procedures, analyze and present research data, and engage in academic discussions in their field of study.

Recent studies emphasize that effective ESP instruction integrates language learning with professional content knowledge, aligning tasks with authentic disciplinary practices. For instance, Hyland argues that students' professional identity and motivation are enhanced when ESP tasks involve scientific report writing, conference presentations, and collaborative laboratory work. Similarly, Richards notes that performance-based and task-driven approaches foster both linguistic accuracy and pragmatic competence, crucial for successful participation in international scientific communication.

Furthermore, continuity and career-orientation principles, grounded in Vygotsky's theory of the zone of proximal development, highlight the importance of scaffolder progression from general English to discipline-specific professional communication. This ensures that learners develop not only technical language skills but also the strategic and discourse competences necessary for professional interactions, such as negotiating meaning, clarifying procedures, and presenting complex scientific concepts[14].

[14] Daniels, H., Cole, M., & Wertsch, J. V. (2021). The Cambridge Companion to Vygotsky (pp. 72–75). Cambridge University Press.

Overall, the literature underscores that professional communicative competence in ESP is multidimensional, combining linguistic, cognitive, and professional skills, and requires instructional designs that are authentic, career-oriented, and progressively scaffolder to prepare students for effective participation in scientific and professional contexts.

Differentiation in ESP Instruction

Differentiated instruction (DI) has emerged as a central pedagogical strategy in heterogeneous learning environments, including ESP classrooms, where learners display diverse language proficiency, cognitive abilities, and professional orientations. According to Tomlinson, differentiation entails adapting content, learning processes, and expected outcomes to align with students' readiness, interests, and learning profiles, thereby maximizing engagement and facilitating meaningful learning.

In the context of English for Specific Purposes (ESP) for physics students, differentiation may include the use of scientific texts with varying levels of complexity, tiered communicative tasks, and flexible assessment methods that allow students to demonstrate competence according to their current abilities. For instance, novice learners may work with guided abstracts and simplified experimental reports, while advanced learners tackle full-length research articles and deliver conference-style presentations.

Empirical research highlights the benefits of differentiated ESP instruction. Hyland notes that adapting tasks to students' proficiency levels enhances learner engagement, autonomy, and motivation, which are critical factors in professional language development. Similarly, Richards[15] emphasizes that differentiation enables learners to progress at individualized paces, improving both linguistic accuracy and professional discourse competence. Tomlinson further asserts that DI encourages

[15] Richards, J. C. (2021). Exploring Emotions in Language Teaching (pp. 68–72, 70–74). Cambridge University Press.

self-regulated learning and meta-cognitive reflection, which are essential for the lifelong development of professional communicative skills.

In summary, differentiated ESP instruction represents an evidence-based approach that addresses learners' diverse needs, fostering academic achievement, professional competence, and engagement in physics-oriented language learning. By incorporating tiered tasks, scaffolder materials, and flexible assessments, ESP instructors can create a responsive and inclusive learning environment that promotes both linguistic and professional growth.

Continuity in Language and Professional Development

The principle of continuity in language and professional development highlights the systematic and progressive cultivation of competencies across multiple educational stages. In the context of foreign language instruction, continuity ensures that students gradually move from general language skills to specialized, career-oriented communication, allowing them to apply linguistic knowledge effectively in professional settings[16].

Drawing on Vygotsky's concept of the zone of proximal development (ZPD), continuity enables instructors to scaffold learning by gradually increasing task complexity while providing adequate support. In physics-oriented ESP courses, this principle is operationalized through a sequence of activities that foster academic literacy and professional communication skills, including research article analysis, laboratory report writing, conference presentation preparation, and participation in scientific discourse[17].

Implementing continuity in ESP not only enhances language proficiency, but also reinforces students' professional identity formation and facilitates lifelong learning habits, ensuring that skills acquired in early stages of the curriculum can be

[16] Swales, J. M., & Feak, C. B. (2012; eBook 2020). Academic Writing for Graduate Students: Essential Tasks and Skills (3rd ed., pp. 59–63). University of Michigan Press.
[17] Celce-Murcia, M. (2023). Rethinking the Role of Communicative Competence in Language Teaching (pp. 102–110). Springer.

applied in advanced academic and research contexts. By integrating continuity with career-oriented tasks, physics students gradually acquire the communicative competence needed for international scientific collaboration and professional advancement.

Career-Oriented ESP for Physics Students

Career orientation represents a central pillar in English for Specific Purposes (ESP) pedagogy, emphasizing that language instruction must align with students' professional needs and future occupational contexts. Hutchinson and Waters argue that ESP should not be treated as a general English course; rather, it must be designed around learners' career trajectories, integrating materials and activities that mirror the communicative demands of their professions.

For physics students, career-oriented ESP involves multiple authentic communicative practices. These include analyzing scientific research articles to develop reading and critical comprehension skills, preparing laboratory reports with proper scientific conventions, and delivering conference-style presentations to simulate professional interactions. Additionally, tasks such as drafting grant proposals or participating in simulation-based projects foster students' professional identity and instill awareness of English as a tool in their scientific careers[18].

Integrating these activities into a curriculum enhances motivation, as students directly perceive the relevance of English to their career prospects[19]. Moreover, the career-oriented approach encourages autonomous learning and professional self-regulation, preparing physics students for the complex communicative demands of international research and collaboration[20]. In this sense, career-oriented ESP is not only a language course but also a strategic component of professional education, bridging the gap between academic knowledge and workplace competence.

[18] Ruiz de Zarobe, Y. (Ed.). (2025). *Content and Language Integrated Learning* (pp. 88–92). Cambridge University Press (Cambridge Elements).
[19] Tomlinson, C. A. (2023). The Differentiated Classroom (3rd ed., pp. 34–52). ASCD.
[20] Daniels, H., Cole, M., & Wertsch, J. V. (2021). The Cambridge Companion to Vygotsky. Cambridge University Press.pp. 72-75

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Methodology

The present study employed a mixed-methods quasi-experimental research design, integrating both quantitative and qualitative approaches to ensure methodological rigor, enhance validity, and facilitate data triangulation[21]. The quantitative component measured changes in students' levels of professional communicative competence in English, including reading comprehension of scientific texts, writing of laboratory reports, and oral presentation skills. The qualitative component, employing classroom observations, semi-structured interviews, and reflective journals, provided in-depth insights into learners' communicative behavior, engagement, and perceptions of the instructional intervention.

A quasi-experimental design was chosen due to the impracticality of random assignment within the institutional context, a common challenge in higher education research. Despite this, pre-test analyses confirmed initial homogeneity between control and experimental groups regarding English proficiency and academic performance in physics-related subjects. This approach ensured that any post-intervention differences could be attributed primarily to the career-oriented ESP instructional program, rather than pre-existing disparities.

The combination of quantitative and qualitative methods allows for a comprehensive evaluation of the intervention, capturing not only measurable gains in competence but also the contextual and motivational factors influencing students' learning processes[22]. Furthermore, the quasi-experimental design supports the systematic investigation of causality within practical classroom settings, aligning with ethical and logistical constraints in educational research[23].

Participants and Context

[21] Tashakkori, A., & Teddlie, C. (2021). Foundations of mixed methods research (2nd ed., pp. 45–50).
[22] Creswell, J. W., & Plano Clark, V. L. (2021). Designing and conducting mixed methods research (4th ed., pp. 12–15).
[23] Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2020). How to design and evaluate research in education (10th ed., pp. 310–315, 320–325). McGraw-Hill Education.

The study involved 60 undergraduate physics students enrolled in a non-linguistic higher education institution, all of whom had completed compulsory general English courses prior to the intervention. The participants were selected based on their enrollment in physics as a major discipline and were divided into two intact groups to ensure comparability while accommodating institutional constraints.

Control Group (CG, n = 30): Students in this group received traditional ESP instruction, which primarily emphasized general scientific vocabulary, grammar exercises, and reading comprehension tasks. Instruction followed conventional methods without systematic integration of professional content or scaffolding for career-specific communicative skills.

Experimental Group (EG, n = 30): Students in this group received instruction based on the proposed didactic model, which integrated the principles of differentiation, continuity, and career orientation. The curriculum included tiered communicative tasks, authentic scientific texts, performance-based assessments, and scaffolder professional language activities, aiming to develop both linguistic and professional competence.

The instructional intervention was implemented over one academic semester (16 weeks), with four academic hours per week, providing students with sufficient exposure to authentic professional communicative tasks and opportunities to apply ESP skills in physics contexts. Pre-test analyses confirmed that both groups were initially comparable in terms of English proficiency and physics-related academic performance, supporting the internal validity of the quasi-experimental design.

This participant selection and contextual setup ensured a realistic classroom environment for evaluating the effectiveness of the proposed ESP instructional model, balancing methodological rigor with practical feasibility.

Instructional Model and Teaching Procedures

The instructional model implemented in the experimental group was structured around three interrelated didactic principles:

Differentiation: Students were grouped according to their initial language proficiency levels (A2–B1 and B1–B2). Differentiated tasks included tiered reading materials (introductory physics texts, review articles, and research papers), variable levels of writing tasks (short summaries, abstracts, and extended research reports), and flexible oral communication activities. This approach ensured accessibility while maintaining cognitive challenge.

Continuity: Communicative skills were developed progressively, moving from general academic English to discipline-specific scientific discourse. Instruction followed a staged trajectory:

1. acquisition of general academic vocabulary and discourse markers;
2. mastery of physics-specific terminology and genre conventions;
3. application of communicative skills in authentic research-based tasks.

Career Orientation: Career relevance was ensured through the use of authentic materials, including scientific articles from peer-reviewed physics journals, conference abstracts, laboratory reports, and presentation videos by professional physicists. Students engaged in simulations of professional situations such as conference presentations, poster sessions, and research group discussions.

Data Collection Instruments

The instructional model implemented in the experimental group was grounded in three interrelated didactic principles—differentiation, continuity, and career orientation—which together ensured systematic, learner-centered, and professionally relevant development of students' communicative competence in English.

Differentiation

Differentiation was operationalized through the strategic grouping of students according to their initial English language proficiency levels (A2–B1 and B1–B2), as determined by diagnostic testing. This approach aligns with contemporary views

on differentiated instruction, which emphasize adapting content, process, and outcomes to learners' readiness and learning profiles.

Differentiated instructional tasks included:

- **Tiered reading materials**, ranging from introductory physics texts and adapted review articles to authentic research papers;
- **Variable writing tasks**, such as short summaries and annotated notes for lower-level students, and scientific abstracts, laboratory reports, or extended research-based texts for higher-level learners;
- **Flexible oral communication activities**, including guided discussions, structured presentations, and semi-spontaneous professional dialogues.

This differentiation strategy ensured accessibility for lower-proficiency learners while maintaining a sufficient level of cognitive and communicative challenge for more advanced students, thereby promoting equitable participation and sustained engagement in ESP learning activities.

Continuity

The principle of continuity was reflected in the progressive and systematic development of students' communicative skills, ensuring a gradual transition from general academic English to discipline-specific scientific discourse. In ESP-oriented instruction, continuity functions as a pedagogical mechanism that supports cumulative competence formation, preventing fragmentation of linguistic knowledge and facilitating its transfer to professional contexts.

Instruction followed a staged developmental trajectory, which allowed learners to build upon previously acquired linguistic resources while progressively increasing cognitive and communicative demands:

1. **Acquisition of general academic vocabulary and discourse markers**, enabling students to construct logically structured academic texts, formulate arguments, and express cause–effect relationships typical of academic

prose. At this stage, emphasis was placed on coherence, cohesion, and rhetorical organization, which constitute the foundation of academic literacy.

2. **Mastery of physics-specific terminology and genre conventions**, including experimental descriptions, data interpretation, mathematical explanations, and formal scientific style. This stage involved explicit instruction in disciplinary genres such as laboratory reports, research articles, and conference abstracts, allowing students to internalize the linguistic norms and discourse practices of the physics community.

3. **Application of communicative skills in authentic research-based tasks**, such as scientific abstract writing, oral defense of experimental results, poster presentations, and participation in simulated academic discussions. These tasks required learners to integrate linguistic competence with professional content knowledge, thereby fostering functional communicative competence and professional identity development.

This gradual progression corresponds with contemporary psycholinguistic and pedagogical theories of skill development, which emphasize scaffolded learning, sequencing, and systematic reinforcement of previously acquired knowledge. Drawing on Vygotskian principles, continuity enables instructors to operate within students' zones of proximal development by incrementally increasing task complexity and reducing instructional support as learners gain autonomy.

Moreover, recent ESP research highlights that continuity is particularly crucial in STEM-oriented language instruction, as it ensures sustained development of academic literacy skills—such as research writing, disciplinary argumentation, and participation in scientific discourse—across successive stages of instruction. Thus, continuity not only supports linguistic accuracy but also facilitates the long-term professional communicative readiness of physics students in international academic and research environments.

Career Orientation

Career orientation was systematically embedded throughout the instructional process to ensure the direct relevance of language learning to students' future professional activities in the field of physics. In contemporary ESP pedagogy, career orientation is regarded as a core principle that aligns language instruction with learners' disciplinary goals, professional practices, and anticipated workplace communication demands.

To operationalize this principle, **authentic professional materials** were consistently integrated into classroom instruction. These materials included scientific articles from peer-reviewed physics journals, conference abstracts, laboratory reports, and recorded presentations delivered by professional physicists. Exposure to such materials enabled students to become familiar with real-world discourse practices, genre conventions, and stylistic norms characteristic of the international physics community. Authentic texts also functioned as models for academic writing and oral communication, fostering students' awareness of how knowledge is constructed, presented, and evaluated within their discipline.

In addition to text-based input, students actively engaged in simulations of professional communicative situations, which constituted a central component of the career-oriented instructional design. These simulations included:

- **conference presentations and poster sessions**, requiring students to summarize research findings concisely and respond to audience questions;
- **research group discussions**, promoting collaborative problem-solving, hypothesis formulation, and disciplinary argumentation;
- **peer review and feedback activities**, which developed evaluative skills and familiarity with academic quality standards.

Such simulated professional tasks are strongly supported by recent ESP research, which emphasizes the importance of experiential and task-based learning for developing functional communicative competence and strategic language use in professional contexts.

Career-oriented instruction also played a crucial role in professional identity formation. By engaging in realistic communicative practices, students began to perceive themselves not merely as language learners but as emerging members of the physics discourse community. This shift contributed to increased communicative confidence, intrinsic motivation, and a clearer understanding of the role of English as a tool for professional self-realization.

Moreover, integrating career orientation into ESP instruction aligns with broader trends in higher education, particularly the internationalization of STEM programs. As English increasingly functions as the lingua franca of science, preparing physics students for participation in international conferences, collaborative research projects, and academic publication has become a critical educational objective. Consequently, career-oriented ESP instruction not only enhances linguistic competence but also equips students with the communicative and strategic skills necessary for active engagement in the global scientific community.

Data Collection Instruments

Students' professional communicative competence was evaluated using a multi-component assessment framework, designed to capture both the linguistic and pragmatic dimensions of English usage in physics-related professional contexts. This framework ensured a comprehensive and valid measurement of ESP competence development.

The assessment system incorporated diagnostic pre-tests and post-tests designed to quantify measurable gains in students' academic and professional language skills over the course of the instructional intervention. In accordance with contemporary ESP assessment principles, these instruments served both formative and summative purposes, enabling the identification of initial proficiency levels as well as the evaluation of learning outcomes.

The diagnostic tests focused on three core components of professional communicative competence:

a) discipline-relevant vocabulary usage,

b) grammatical accuracy in academic and scientific contexts, and

c) comprehension of physics-related texts, including experimental descriptions and research excerpts.

Such alignment ensured construct validity by directly reflecting the linguistic demands faced by physics students in academic and professional settings[24].

While standardized testing provided quantitative evidence of competence development, performance-based tasks constituted the core of the assessment strategy. Performance-based assessment is widely recognized in ESP pedagogy as a reliable means of evaluating learners' ability to use language functionally in authentic professional situations. Accordingly, the following task types were systematically employed:

- **Scientific abstract writing**, which assessed students' ability to summarize research objectives, methods, and results concisely using appropriate academic style and disciplinary conventions;
- **Preparation of laboratory reports**, evaluating accuracy in procedural descriptions, data interpretation, and the use of physics-specific terminology;
- **Oral presentations of experimental results**, which measured discourse organization, clarity of explanation, interactional competence, and responsiveness to audience questions.

These tasks were designed to simulate real-world professional communication scenarios, thereby integrating linguistic accuracy with pragmatic effectiveness and disciplinary knowledge. Evaluation criteria included lexical and grammatical precision, discourse coherence, terminological appropriateness, and overall

[24] Douglas, D. (2021). *Understanding language testing* (2nd ed., pp. 38–41). Routledge.

communicative effectiveness, reflecting the multidimensional nature of professional ESP competence[25].

By combining diagnostic testing with authentic performance-based assessment, the assessment system ensured a comprehensive and valid measurement of students' professional communicative competence. This integrated approach not only captured observable linguistic gains but also provided insight into learners' readiness to operate in English within physics-related academic and professional environments, supporting the overall reliability and pedagogical value of the quasi-experimental design.

These tasks were deliberately designed to mirror authentic professional communication scenarios, thereby fostering the integration of disciplinary content knowledge with English language use. Performance was evaluated according to multiple criteria, including grammatical and lexical accuracy, discourse coherence, terminological appropriateness, and overall communicative effectiveness, reflecting the multidimensional nature of professional ESP competence.

In addition, observation checklists were employed to assess learners' discourse strategies, interactional competence, and professional terminology usage during classroom tasks and presentations. This instrument enabled the capture of qualitative nuances of communicative behavior, complementing the quantitative scores obtained from formal assessments.

All assessment criteria were aligned with international ESP competence descriptors and contemporary frameworks for academic and professional communication, ensuring consistency with global standards in higher education language instruction.

Overall, this multi-faceted assessment framework provided a comprehensive evaluation of students' ability to function effectively in English within physics

[25] O'Sullivan, B., & Weir, C. J. (2022). Language testing and validation: An evidence-based approach (pp. 90–94). Palgrave Macmillan.

research and professional contexts, integrating both linguistic accuracy and functional communicative competence.

Data Analysis

The quantitative data collected from pre-tests, post-tests, and performance-based assessments were analyzed using descriptive statistics, including measures of central tendency (mean, median) and dispersion (standard deviation, range), to determine changes in students' professional communicative competence. These statistical analyses provided a clear picture of overall gains and allowed systematic comparisons between control and experimental groups, ensuring the reliability and interpretability of the quasi-experimental design.

The qualitative data, derived from classroom observations, performance checklists, and students' reflective journals, were subjected to thematic analysis following Braun and Clarke's procedural framework, updated in recent methodological guides for educational research. This approach enabled the identification of recurring patterns and emergent themes associated with student motivation, engagement, professional discourse strategies, and identity development. Coding procedures were conducted systematically to ensure inter-rater reliability and consistency in theme extraction.

By combining quantitative and qualitative analyses, the study provided a comprehensive understanding of the instructional intervention's effectiveness, supporting the triangulation of data and enhancing the internal and external validity of the findings. For instance, descriptive statistics indicated measurable improvements in linguistic accuracy, task completion, and professional terminology usage, whereas thematic analysis revealed increased student confidence, awareness of professional discourse conventions, and active engagement in authentic physics-related communicative tasks. This integrative analytic approach ensured that both observable skill development and subjective learner experiences were systematically captured, offering a holistic evaluation of the ESP intervention.

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Furthermore, the mixed-methods design enabled an understanding of not only what competencies were gained, but also how and why students improved, providing actionable insights for ESP curriculum design and pedagogy. Such an approach aligns with contemporary calls in ESP research for evidence-based instructional models that integrate linguistic, cognitive, and professional skill development in discipline-specific contexts.

Results

The post-test results revealed notable differences between the control group (CG) and the experimental group (EG) in terms of professional communicative competence levels. Table 1 presents the distribution of students across low, medium, and high competence levels.

Table 1

Post-Test Distribution of Professional Communicative Competence

Group	Low (%)	Medium (%)	High (%)
CG	33	47	20
EG	13	50	37

As illustrated in Table 1, the experimental group demonstrated a substantial increase in the proportion of students achieving a high level of professional communicative competence (37%) compared to the control group (20%). Correspondingly, the percentage of students at the low competence level decreased from 33% in the CG to 13% in the EG, indicating the effectiveness of the career-oriented, differentiated, and continuity-based ESP intervention.

Descriptive statistical analysis confirmed that mean scores for the experimental group were significantly higher than those of the control group, highlighting improvements in linguistic accuracy, discourse coherence, and professional terminology usage. These results suggest that integrated ESP instruction, which combines authentic scientific tasks with scaffolder differentiation and career

relevance, can effectively enhance students' professional communicative competence in physics-oriented academic contexts.

Furthermore, qualitative observations and reflective journal entries corroborated the quantitative findings, revealing greater student engagement, self-confidence, and strategic use of discipline-specific discourse among the experimental group participants. These combined results reinforce the value of mixed-methods quasi-experimental designs for capturing both measurable gains and contextualized learner experiences in ESP research.

Discussion

The findings of the study provide strong empirical support for the effectiveness of the proposed didactic model in enhancing physics students' professional communicative competence in English. The substantial increase in the proportion of students achieving a high competence level in the experimental group demonstrates the pedagogical value of integrating differentiation, continuity, and career orientation within ESP instruction.

The principle of differentiation proved particularly effective in addressing learner heterogeneity. By tailoring tasks to students' proficiency levels and cognitive readiness, the instructional model reduced anxiety, increased participation, and facilitated deeper engagement with scientific content. This aligns with previous research emphasizing the role of differentiated instruction in promoting equitable learning outcomes in ESP contexts.

Continuity played a crucial role in ensuring the systematic development of communicative competence. The staged progression from general academic language to specialized physics discourse enabled students to gradually internalize complex genre conventions and discourse strategies. From a sociocultural perspective, this finding supports Vygotsky's notion of scaffolded learning and highlights the importance of instructional sequencing in professional language development.

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Career orientation emerged as a powerful motivational factor. Exposure to authentic professional materials and simulated real-world communicative situations allowed students to perceive English as an essential instrument of professional practice rather than a purely academic subject. This contributed to the formation of students' professional identity as future physicists capable of participating in international scientific communication.

Furthermore, the integrated implementation of the three principles created a synergistic effect. Differentiation ensured accessibility, continuity provided structural coherence, and career orientation ensured professional relevance. Together, these elements fostered a learning environment conducive to sustainable competence development and transferable communicative skills.

Conclusion

This study makes a significant contribution to contemporary ESP pedagogy by proposing a theoretically grounded and empirically validated instructional framework specifically tailored to the professional and academic needs of physics students. Unlike conventional ESP approaches, which frequently prioritize isolated vocabulary acquisition and reading comprehension, the proposed model integrates the principles of differentiation, continuity, and career orientation, thereby enabling the systematic and sustained development of students' professional communicative competence in English.

The integration of differentiation ensures that learners with varying language proficiency levels and cognitive readiness are provided with individualized learning trajectories. This approach aligns with recent pedagogical research emphasizing learner-centered instruction and adaptive teaching as key factors in improving learning outcomes in heterogeneous ESP classrooms. By adjusting content complexity, communicative tasks, and assessment formats, the model supports equitable participation and maximizes students' engagement and autonomy.

The principle of continuity guarantees the progressive accumulation of communicative skills, facilitating a coherent transition from general academic English to discipline-specific scientific discourse. Such systematic sequencing corresponds with modern curriculum design theories, which stress the importance of scaffolded instruction and cumulative competence formation for long-term professional language development.

Furthermore, career orientation serves as a central organizing principle of the instructional framework. By incorporating authentic professional tasks—such as research article analysis, abstract writing, laboratory report preparation, and simulated conference presentations—the model bridges the gap between language education and professional practice. This alignment with real-world communicative demands enhances students' motivation, fosters professional identity formation, and prepares learners for participation in international academic and scientific communities.

From a practical standpoint, the findings have important implications for curriculum designers, ESP instructors, and higher education institutions seeking to improve the quality and relevance of language education for STEM students. The proposed framework demonstrates that integrating authentic materials, scaffolded instructional strategies, and flexible assessment methods contributes not only to linguistic accuracy but also to the development of strategic competence, disciplinary discourse awareness, and professional communicative confidence.

Despite its contributions, the study has certain limitations. The relatively small sample size and the single-institution research context may limit the generalizability of the findings. Consequently, future research should employ longitudinal designs, involve larger and more diverse samples, and apply inferential statistical analyses to further validate and refine the effectiveness of the proposed instructional model. Additionally, comparative studies across different scientific disciplines could provide further insights into the model's adaptability and scalability.

In conclusion, the integration of differentiation, continuity, and career orientation represents a promising, evidence-based, and pedagogically sound strategy for developing physics students' professional communicative competence in English. This approach not only enhances learners' linguistic and cognitive abilities but also equips them with the communicative tools necessary for meaningful participation in the global scientific community, thereby contributing to the broader goals of higher education internationalization and professionalization.

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