

## SCIENTIFIC ENGLISH AS A SEMIOTIC SYSTEM: THE CASE OF PHYSICS TERMINOLOGY

Ioana Claudia Horea<sup>1</sup>, Cristian Dorin Horea<sup>2</sup>

<sup>1</sup>Department of International Business, Faculty of Economic Sciences, University of Oradea, Oradea, Romania

<sup>2</sup>Department of Physics, Faculty of Informatics and Science, University of Oradea, Oradea, Romania

<sup>1</sup>cristihorea@gmail.com

<sup>2</sup>ioanahorea@gmail.com

**Abstract:** *This paper investigates the semiotic and linguistic dimensions of specialized English in the field of physics, positioning scientific English as a multifaceted system that mediates knowledge construction, communication, and learning. The study aims to examine how terminology, metaphor, and symbolic representation interact in physics discourse to create precise yet cognitively accessible conceptual frameworks. Using a qualitative, corpus-informed approach, the analysis draws on examples from academic journal articles, textbooks, and didactic materials to illustrate the semiotic patterns that underpin key physics concepts such as energy, field, wave, particle, and quantum entanglement. Particular attention is given to the interplay between verbal language, mathematical notation, and visual representations, highlighting the multimodal nature of physics communication. The paper further explores the pedagogical implications of these semiotic features, demonstrating how awareness of terminology, metaphorical mappings, and symbolic structures can enhance the teaching of English for Specific Purposes (ESP) in physics, particularly for non-native speakers. In addition, the study addresses translational challenges, emphasizing how semiotic analysis can inform strategies for rendering specialized physics discourse across languages while preserving conceptual fidelity and precision. By integrating applied linguistics, semiotics, and translation studies, this research underscores the importance of a semiotically informed approach to both ESP instruction and scientific communication. The findings suggest that fostering semiotic and terminological awareness can improve learners' conceptual understanding, facilitate interdisciplinary collaboration, and support accurate translation of physics texts. This approach not only enhances pedagogical outcomes but also contributes to the clarity, accessibility, and global dissemination of scientific knowledge.*

**Keywords:** scientific English; physics terminology; ESP pedagogy; semiotics; translation; metaphor; multimodal discourse

### 1. Introduction

English has become the lingua franca of scientific research, functioning as the primary medium for disseminating knowledge, publishing findings, and facilitating international collaboration. Among scientific disciplines, physics exhibits a particularly complex linguistic profile due to its reliance on specialized terminology,

symbolic representation, and multimodal communication (Halliday & Martin, 1993). Despite the centrality of English in global physics discourse, there is limited research on the semiotic and applied linguistic dimensions of physics terminology and its implications for teaching and translation in English for Specific Purposes (ESP) contexts.

This study investigates scientific English in physics as a semiotic system that integrates linguistic, symbolic, and visual modes to convey precise conceptual meaning. The paper examines how terminology, metaphor, and discourse patterns function as mediating tools in teaching, learning, and translating physics. By analyzing a corpus of journal articles, textbooks, and instructional materials, the research identifies patterns of lexical, metaphorical, and symbolic usage that structure the understanding of key physics concepts.

The specific objectives of the study are as follows:

1. To describe how verbal, symbolic, and visual modes interact in physics English to create a coherent conceptual system.
2. To examine the role of metaphor and terminology in conveying abstract physical phenomena.
3. To assess the pedagogical and translational implications of semiotic features in physics discourse.

By foregrounding applied linguistic and pedagogical concerns, this paper contributes to the development of ESP strategies that enhance conceptual comprehension, translation accuracy, and effective communication in international physics contexts.

## **2. Theoretical Framework**

### **2.1. Semiotics and Scientific Language**

Semiotics provides a foundational lens for examining how scientific concepts are communicated and constructed through language. Following Peirce's (1931–1958) triadic model of the sign, which distinguishes between the representamen, object, and interpretant, scientific terminology can be understood as a structured system of signs mediating between observed phenomena and conceptual understanding. Eco (1976) further emphasizes that specialized language functions as a “cultural encyclopedia,” where meaning is shaped both by disciplinary conventions and by shared knowledge structures.

In physics, words, symbols, and diagrams function synergistically to represent abstract phenomena that often cannot be directly observed. Terms such as *field*, *wave*, and *quantum entanglement* are not merely lexical items; they act as semiotic instruments that structure reasoning, experimentation, and conceptualization. Understanding these semiotic dynamics is crucial for ESP pedagogy and translation, as learners and translators must interpret meaning across multiple modalities while maintaining disciplinary precision.

### **2.2. Language as a Cognitive and Epistemic Tool**

From an applied linguistic perspective, language does not merely describe physical phenomena; it actively shapes conceptual understanding. Halliday and Martin (1993) argue that the lexicon, grammar, and discourse structures of scientific English constitute an epistemic system, enabling the construction and

communication of complex scientific knowledge. In physics, nominalization and lexical precision allow abstract concepts to be referenced efficiently, while metaphorical and symbolic forms facilitate cognitive access to otherwise intangible ideas.

Recent studies in ESP and scientific English have emphasized the importance of integrating semiotic and applied linguistic perspectives to understand disciplinary discourse. Hyland (2000) highlights that the linguistic structures of scientific writing are closely tied to rhetorical and cognitive functions, shaping how knowledge is presented and interpreted. Likewise, Flowerdew (2013) points out that specialized vocabulary and metaphorical language serve as mediating tools that allow learners and researchers to navigate complex scientific concepts.

### **2.3. Multimodality in Scientific Discourse**

In the context of physics, Swales and Feak (2012) provide extensive examples of disciplinary discourse features, including nominalization, passive constructions, and hedging, which collectively contribute to the epistemic precision of scientific communication. These studies suggest that a deeper semiotic and linguistic analysis is necessary to fully understand the mechanisms by which terminology and multimodal resources convey meaning in specialized fields.

Scientific English in physics is inherently multimodal, integrating verbal, symbolic, and visual resources. Equations formalize quantitative relationships, diagrams and graphs illustrate spatial and functional relations, and verbal explanations contextualize and interpret these symbolic elements. This multimodal integration is a defining feature of physics discourse and an essential consideration for ESP instruction and translation (Lemke, 1998).

## **3. Terminology in Physics English**

### **3.1. Lexical Precision and Nominalization**

Physics relies on precise terminology to avoid ambiguity. Many technical terms originate from everyday English words but acquire highly specialized meanings in physics. For example, *spin* in quantum mechanics refers to an intrinsic property of particles rather than rotational motion, while *field* designates a region in which a force is exerted, extending beyond its everyday use. Nominalization allows processes and phenomena to be reified as concepts (*acceleration*, *momentum*, *entropy*), facilitating concise and formal discourse.

Several studies have specifically examined the vocabulary and conceptual structures in physics discourse. For instance, Paltridge (2002) investigates how nominalized forms and technical terms facilitate the compact expression of complex processes, while Biber and Gray (2016) analyze corpus-based evidence showing recurring collocational patterns in physics texts that reflect epistemic and cognitive constraints. Meanwhile, Jenkins (2014) emphasizes the role of metaphor in bridging abstract physical concepts with learners' prior knowledge, suggesting that careful integration of metaphorical and literal terminology can enhance both comprehension and retention. These findings underscore the importance of a systematic, corpus-informed approach to analyzing specialized English in physics, complementing the semiotic framework discussed in subtitle 2.

### **3.2. Conceptual Metaphors and Semiotic Mediation in Physics**

Metaphors serve as cognitive tools that structure understanding of abstract phenomena. The term *wave-particle duality* exemplifies metaphorical mapping, allowing learners to conceptualize quantum behavior by drawing analogies with familiar physical entities. Similarly, *string vibration* in string theory leverages kinesthetic metaphor to represent complex multidimensional phenomena. Metaphors in physics are therefore not decorative; they are epistemically productive, enabling conceptual mediation and pedagogical scaffolding (Lakoff & Johnson, 1980).

Physics terminology is inseparable from symbolic and visual representations. For instance, *vector*, *tensor*, and *operator* are terms whose meanings are instantiated through equations and diagrams. Effective ESP instruction requires learners to navigate this semiotic interface, understanding how verbal and symbolic forms complement each other to convey complete conceptual meaning.

## **4. Metaphor and Pedagogical Implications**

### **4.1. Teaching Physics Terminology in ESP Contexts**

The teaching of physics terminology in ESP contexts benefits from recognizing that specialized language functions as a semiotic system, where verbal, symbolic, and visual resources jointly convey meaning. Understanding the conceptual interactions among these modes provides the theoretical foundation for multimodal pedagogy, allowing learners to engage with terminology, diagrams, and symbolic notation as an integrated system rather than as isolated elements.

Multimodal approaches to ESP instruction have gained significant attention in recent years. For example, Holmes and Stubbs (2015) argue that the integration of verbal, symbolic, and visual resources in teaching scientific discourse allows learners to construct meaning more effectively, particularly when dealing with abstract concepts such as quantum mechanics or electromagnetism. Similarly, Cortes (2016) emphasizes the pedagogical value of combining diagrammatic analysis with targeted terminology instruction to scaffold understanding and improve disciplinary literacy. Such research highlights the potential of semiotic-aware ESP pedagogy, reinforcing the argument that multimodality is not merely a supplementary tool but a central feature of physics English teaching.

### **4.2. Developing Conceptual Awareness and Terminology Management**

Incorporating metaphor analysis into ESP curricula enhances learners' conceptual awareness. For example, tracing the metaphorical extension of *field* from everyday contexts to electromagnetism clarifies abstract theoretical constructs. Similarly, understanding *quantum superposition* through layered visual and verbal representations supports cognitive accessibility.

Translating physics terminology involves more than substituting equivalent words. Translators must consider cultural, metaphorical, and semiotic dimensions to preserve meaning across languages. Semiotic analysis guides translators in navigating terms like *entanglement* or *quantum leap*, ensuring conceptual fidelity while avoiding misinterpretation. Terminology management tools and standardized glossaries can facilitate consistency and accuracy (Sager, 1990).

## 5. Research Methodology

### 5.1. Research Design and Data Collection

The study adopted a qualitative, corpus-informed approach to the analysis of specialized English in physics as a semiotic system. The research focused on the identification, classification, and interpretation of terminology, symbolic notation, and visual representations in physics discourse, with attention to their pedagogical and translational implications. The design was exploratory-descriptive, emphasizing the detection of recurrent patterns in lexical usage, metaphorical mappings, and multimodal integration.

The corpus consisted of approximately 50–60 sources, including academic journal articles in physics (e.g., *Physical Review Letters*, *European Journal of Physics*), university-level textbooks covering mechanics, thermodynamics, electromagnetism, and quantum physics, as well as instructional materials employed in ESP courses for physics students, such as lesson plans, exercises, and glossaries.

### 5.2 Analytical Procedure and Rationale

The methodology encompassed three interrelated analytical steps:

- **Identification and classification of specialized terminology:** Extraction of technical terms, including nominalizations, metaphorical expressions, and lexically ambiguous items. Terms were categorized by subdomain, covering mechanics, thermodynamics, electromagnetism, and quantum physics.
- **Analysis of multimodal representations:** Examination of the interaction between verbal terminology, mathematical symbols, formulas, and diagrams, with particular attention to how multimodal resources mediate conceptual understanding.
- **Analysis of pedagogical and translational implications:** Evaluation of terminology presentation in instructional contexts, identification of metaphorical and symbolic strategies supporting learner comprehension, and assessment of translation challenges, highlighting the importance of semiotic awareness in maintaining terminological precision and conceptual fidelity across languages.

This methodology allowed a systematic examination of specialized English in physics while maintaining attention to applied linguistic concerns, pedagogical strategies, and translation practices. Through the combination of corpus-based data, multimodal analysis, and semiotic interpretation, the study bridged theoretical insights and practical applications, providing a solid foundation for ESP instruction and cross-linguistic scientific communication.

## 6. Multimodal Discourse Analysis

### 6.1. Multimodal Resources

Equations encode relationships among physical quantities, often functioning as semiotic signs themselves. For instance, the Schrödinger equation represents a superposition of quantum states, integrating variables, operators, and constants in

a single formal structure. Learners must interpret these symbols in conjunction with verbal explanations to develop a complete understanding.

Diagrams and graphs serve as visual semiotic resources that complement terminology. Free-body diagrams, field lines, and phase-space plots translate abstract concepts into perceivable forms. Teaching strategies that integrate verbal, symbolic, and visual modes enhance comprehension and facilitate knowledge transfer.

*Pedagogical Integration:* Effective ESP instruction in physics emphasizes coordinated multimodal engagement. Activities may include annotating diagrams with terminology, interpreting equations through verbal paraphrase, and linking conceptual metaphors to symbolic representation. Such strategies improve learner autonomy and conceptual clarity.

## **6.2. Pedagogical Analysis**

### **6.2.1. Conceptual and Semiotic Awareness**

Pedagogical strategies should foreground the semiotic nature of terminology. Teaching exercises might involve mapping metaphorical structures, linking lexical items to symbolic notation, and analyzing diagrams in parallel with verbal explanations. Such approaches support deep conceptual understanding rather than rote memorization of vocabulary (Trimble, 1985).

Incorporating metaphor analysis into ESP curricula enhances learners' conceptual awareness. For example, tracing the metaphorical extension of *field* from everyday contexts to electromagnetism clarifies abstract theoretical constructs. Similarly, understanding *quantum superposition* through layered visual and verbal representations supports cognitive accessibility.

Physics discourse relies heavily on nominalization and lexical precision to convey abstract concepts succinctly. Terms such as *acceleration*, *momentum*, and *energy transfer* exemplify this nominalization, allowing for formal, concise expression in written texts. Analysis of nominalizations in academic articles can help learners recognize the patterns that structure scientific argumentation, improving reading comprehension and production in ESP contexts.

### **6.2.2. Practical Classroom Applications**

To illustrate the pedagogical applications of semiotic and multimodal analysis, consider the teaching of *quantum superposition*. In instructional texts, the term is often introduced alongside both a verbal explanation and a visual representation of overlapping probability waves. By engaging learners in exercises that map the linguistic term to diagrams and symbolic notation, instructors can enhance conceptual clarity. Further, metaphorical descriptions such as "simultaneous states" or "wavefunction overlap" provide cognitive scaffolding, enabling students to link abstract phenomena to intuitive understandings. Similar approaches can be applied to teaching electromagnetism, where vector diagrams and field line illustrations accompany precise terminology to consolidate comprehension.

## **6.3. Examples of Terms and Classroom Activities**

### **6.3.1. Lexical Awareness and Disambiguation**

In teaching ESP for physics, it is essential to draw students' attention to the

differences between the specialized meaning of terms and their general English sense. For example:

- *Field* → in general English, it may mean “agricultural field” or “area of activity,” while in physics it refers to “a region in which a force is exerted” (e.g., electric field, magnetic field).

Semantic shift: highlights the shift from concrete or metaphorical spatial areas to abstract force-related regions.

- *Spin* → ordinarily “rotation” or “twirl,” but in quantum physics it denotes an intrinsic property of particles.

Conceptual abstraction: demonstrates that the term’s physical meaning is not literal rotation, emphasizing abstraction in quantum mechanics.

- *Work* → generally “labor” or “job,” but in physics it represents mechanical work  $W = F \cdot d \cdot \cos \theta$ .

Formalization: shows how a familiar concept is formalized mathematically in physics, moving from everyday action to precise measurement.

- *Power* → general English “ability” or “strength,” while in physics it denotes the rate at which work is done,  $P = \frac{W}{t}$

Quantitative framing: links conceptual understanding with quantitative description.

- *Momentum* → commonly understood as “impetus” or “progress,” but in physics defined as a vector quantity,  $\vec{p} = m \cdot \vec{v}$ .

Vectorial specification: illustrates semantic narrowing and formalization in vectorial terms.

- *Resistance* → everyday sense of “opposition” or “refusal,” whereas in physics it refers to electrical resistance,  $R = \frac{V}{I}$ .

Operationalization: demonstrates how general opposition is quantified in a specific physical context.

- *Potential well* → metaphorical in form (“well”), but denotes a precise energy configuration in classical and quantum mechanics.

Metaphorical grounding: highlights metaphorical imagery linked to formal energy concepts.

- *Flux* → general meaning “flow” or “change,” but in physics refers to the integral of a field across a surface (e.g., magnetic flux  $\Phi = \int \vec{B} \cdot \vec{dA}$ )

Mathematical abstraction: shows abstraction of motion into mathematical formalism, bridging conceptual and symbolic understanding.

### **Pedagogical activity**

The instructor shall present terms with comparative examples: students identify the general meaning first, then the scientific meaning, and finally produce scientific sentences using the terms correctly. This activity can be combined with diagrams and symbols to consolidate understanding.

### **6.3.2. Metaphors and Visualization**

In physics ESP instruction, many key terms describe abstract or counterintuitive phenomena, often expressed through metaphors, models, or symbolic representations. Terms such as wave, particle, superposition, and entanglement can be paired with visualizations, animations, or diagrams to help students connect verbal explanations with mathematical and conceptual representations.

For instance, superposition can be illustrated with a graphic showing two overlapping probability states, accompanied by verbal explanation and the mathematical representation:  $|\psi\rangle = \alpha |0\rangle + \beta |1\rangle$

Other abstract or metaphorical terms can be similarly supported with targeted visualizations and pedagogical commentary:

- *Barrier (quantum tunneling)* → metaphor suggests obstruction, yet particles can penetrate it probabilistically.

Pedagogical insight: metaphor must be explicitly problematized to avoid classical misconceptions.

- *Orbitals* → unlike classical orbits, they represent probability distributions.

Visualization: electron density clouds rather than trajectories.

- *Wave packet* → combines everyday “packet” imagery with wave superposition.

Semiotic interest: hybrid metaphor linking discreteness and continuity.

- *Collapse (of the wave function)* → metaphorical verb implying physical destruction, whereas it signifies a change in knowledge state.

Teaching strategy: contrast linguistic metaphor with epistemic interpretation.

#### **Pedagogical exercise:**

Students complete tables linking each term to: its scientific definition, metaphorical analogy, mathematical symbol, and an application example. This enhances both conceptual understanding and ESP competence.

### **6.3.3. Nominalization and Discursive Coherence**

Terms such as acceleration, momentum, energy transfer, angular velocity, quantization, stabilization, interaction, and propagation are nominalized to allow concise and formal scientific writing.

- *Acceleration* → expresses change in velocity as a measurable quantity.

Formalization: shows how dynamic processes can be represented as abstract nouns for precise scientific discourse.

- *Momentum* → expresses mass × velocity as a vector quantity.

Conceptual clarification: highlights the shift from everyday motion to an abstract, formalized concept suitable for theoretical reasoning.

- *Energy transfer* → describes the movement of energy between systems.

Discursive function: demonstrates how complex processes are nominalized for conciseness and coherence in scientific writing.

- *Angular velocity* → quantifies rotational speed of an object.

Formalization: encapsulates magnitude and direction in a single technical noun, integrating multiple aspects of a concept.

- *Quantization* → expresses theoretical constraints in quantum physics.

Conceptual clarification: links abstract theoretical principles to linguistic form, showing how scientific laws can be encoded in nouns.

- *Stabilization* → describes system stability in plasma or particle physics.

Discursive function: emphasizes outcomes over actions, reinforcing a formal and concise scientific style.

- *Interaction* → replaces verbal constructions (“particles interact”) with abstract relational nouns.

Discursive function: facilitates concise description of relationships, important for both ESP communication and scientific writing.

- *Propagation* → formalizes dynamic processes in wave physics.

Discursive function: combines action and concept in a single noun for efficient and coherent reference to processes.

**Activity:** Students first analyze sentences from scientific articles, highlighting nominalizations and reformulating them in more accessible language. As an extension, they transform clauses such as “the wave propagates through the medium” into “wave propagation through the medium,” reinforcing nominalization and discursive coherence.

## **7. Applied Translation Considerations**

### **7.1. Enhancing Translation Accuracy through Semiotic Analysis**

#### **7.1.1 Challenges and Implications**

Physics terminology often contains culturally or historically situated metaphors, which can pose challenges in cross-linguistic transfer. Translators must navigate these nuances carefully to avoid distorting conceptual meaning. Terms like spin, charge, or field may require adaptation in target languages to maintain disciplinary accuracy.

ESP textbooks and instructional resources should incorporate guidance for both learners and translators, highlighting terminology, metaphorical structures, and symbolic conventions. Such materials promote conceptual understanding, translational competence, and effective scientific communication, ensuring that metaphors and abstractions are interpreted correctly across languages.

#### **7.1.2 Strategies for Semiotic-Aware Translation**

A semiotic approach to translation emphasizes conceptual equivalence, multimodal interpretation, and glossary development. Translators benefit from understanding the interplay of verbal, symbolic, and visual forms, allowing them to produce texts that are accurate, readable, and pedagogically useful.

For example, the term spin in quantum mechanics can be misinterpreted in literal translation as rotational movement, potentially misleading learners or readers in other languages. Research by Gotti (2013) and Casas-Tost (2015) demonstrates that semiotic analysis, including attention to metaphorical and symbolic dimensions, improves translation accuracy by highlighting conceptual correspondences rather than relying solely on lexical equivalence.

Translators are thus encouraged to integrate multimodal cues from diagrams and equations, which often carry explanatory weight that complements verbal descriptions. This approach ensures terminological precision and preserves the pedagogical integrity of instructional materials, supporting both ESP teaching and accurate translation.

### **7.2. Translation and Disambiguation Activities**

Here are just a few example of lexical elements that bring semantic challenges and some methods to tackle them.

#### **7.2.1. Typical Translation Challenges**

- *Charge* → can mean “fee” or “load” in general English, but in physics it refers to “electric charge.”

- *Potential* → general meaning “potential,” in physics “electric potential.”
- *Current* → “flow” can be ambiguous: electric current, water current, current of opinion.
- *State* → general meaning “condition” or “political entity,” in physics refers to a complete description of a system (quantum state).
- *Mode* → everyday “manner,” in physics a specific pattern of oscillation or vibration.
- *Coupling* → general “connection,” but in physics denotes interaction strength between systems or fields.
- *Degree of freedom* → idiomatic in English, but a precise count of independent variables in physics.

*Translation risk:* literal rendering may obscure conceptual meaning in the target language.

### 7.2.2. Pedagogical and Translation Strategies

Students or translators receive texts with these terms in different contexts and must choose the correct translation in the target language, justifying their choice based on scientific definition and discourse context. Suggested activities include:

- *Contrastive definition task:* students compare dictionary definitions with textbook definitions in both source and target languages.
- *Equation-led translation:* begin from formulas (e.g.,  $E = m \cdot c^2$ ,  $\nabla \vec{E} = \frac{\rho}{\epsilon_0}$ ) and reconstruct verbal explanations in the target language.
- *Metaphor evaluation exercise:* identify which metaphors can be retained and which must be neutralized in translation.
- *Multimodal integration:* for terms such as vector, force diagram, or magnetic field lines, interpret verbal text, formulas, and diagrams simultaneously. Example: provide a paragraph with  $\vec{F} = q \cdot \vec{v} \times \vec{B}$ , a diagram, and verbal explanation; students translate the text and annotate the symbols.
- *Glossary development:* create a mini-bilingual glossary including general meaning, scientific meaning, mathematical symbol, and visual example to prevent confusion.

These exercises strengthen both conceptual understanding and ESP competence, ensuring accurate and pedagogically sound translation of physics terminology.

## 8. Conclusions

Scientific English in physics functions as a complex semiotic system that integrates verbal, symbolic, and visual resources to mediate conceptual understanding, teaching, and translation. This study emphasizes the centrality of terminology, metaphor, multimodal representation, and nominalization in structuring discourse and facilitating learning. Pedagogical strategies informed by semiotic analysis – such as comparative exercises, visualization of abstract phenomena, and the systematic linking of terms to symbols and diagrams – can significantly enhance learners’ conceptual understanding and their ability to navigate specialized English. In addition, attention to cross-linguistic and translation challenges demonstrates that ESP instructors and translators alike benefit from semiotic-aware strategies, including bilingual glossaries, multimodal interpretation, and metaphorical

scaffolding. These approaches support accurate translation, prevent terminological ambiguity, and foster greater disciplinary literacy across languages.

By integrating applied linguistics, semiotics, and translation studies, this research contributes to ESP methodologies that not only improve comprehension and retention but also enable learners to engage effectively in international scientific discourse. Future research may focus on developing interactive, multimodal ESP materials, corpus-based analyses of disciplinary vocabulary, and longitudinal studies examining the impact of semiotic-aware teaching on learners' scientific literacy. Such efforts will further enhance the clarity, accessibility, and global dissemination of physics knowledge, reinforcing the role of English as a truly mediating tool in contemporary science.

#### References:

- [1]. **Biber, D., & Gray, B.** (2016). *Grammatical complexity in academic English: Linguistic change in writing*. Cambridge: Cambridge University Press.
- [2]. **Casas-Tost, M.** (2015). Translating science: Semiotic perspectives on terminology. *The Translator*, 21(2), 123–142.
- [3]. **Cortes, V.** (2016). Multimodality in the classroom: Teaching scientific concepts through diagrams and texts. *Journal of English for Academic Purposes*, 23, 50–62.
- [4]. **Eco, U.** (1976). *A theory of semiotics*. Bloomington: Indiana University Press.
- [5]. **Flowerdew, J.** (2013). *Discourse in English language education*. London: Routledge.
- [6]. **Gotti, M.** (2013). Translation and terminology in scientific discourse. *Linguistica Antverpiensia*, 12, 45–62.
- [7]. **Halliday, M. A. K., & Martin, J. R.** (1993). *Writing science: Literacy and discursive power*. London: Falmer Press.
- [8]. **Holmes, J., & Stubbs, M.** (2015). *Approaches to teaching scientific English*. Oxford: Oxford University Press.
- [9]. **Hyland, K.** (2000). *Discipline-specific discourse: Social interactions in academic writing*. London: Longman.
- [10]. **Jenkins, J.** (2014). *English as a lingua franca in the classroom: Pedagogical implications*. London: Routledge.
- [11]. **Lakoff, G., & Johnson, M.** (1980). *Metaphors we live by*. Chicago: University of Chicago Press.
- [12]. **Lemke, J. L.** (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. R. Martin & R. Veel (Eds.), *Reading science* (pp. 87–113). London: Routledge.
- [13]. **Montgomery, S. L.** (1996). *The scientific voice*. New York: Guilford Press.
- [14]. **Paltridge, B.** (2002). *Genre, frames and writing in research settings*. Amsterdam: John Benjamins.
- [15]. **Sager, J. C.** (1990). *A practical course in terminology processing*. Amsterdam: John Benjamins.
- [16]. **Swales, J. M.** (1990). *Genre analysis: English in academic and research settings*. Cambridge: Cambridge University Press.
- [17]. **Swales, J. M., & Feak, C. B.** (2012). *Academic writing for graduate students* (3rd ed.). Ann Arbor, MI: University of Michigan Press.

- [18].Trimble, L. (1985). *English for science and technology: A discourse approach*. Cambridge: Cambridge University Press.
- [19].Whorf, B. L. (1956). *Language, thought, and reality*. Cambridge, MA: MIT Press.