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Semantic-terminological aspects of teaching physics as a science and academic discipline: a bilingual approach

Nataliia Azhohina
Department of Foreign Languages for Chemistry and Physics Related Faculties, Taras Shevchenko National University of Kyiv, Ukraine
ORCID: 0000-0001-6249-6118

Abstract: The relevance of the research topic is caused by modern innovations in the field of science and education, especially in physics. Certain changes continue in the semantic and terminological sphere of physics as a science. Of particular interest are bilingual (Ukrainian and English language) processes in the system of higher and postgraduate education in Ukraine, in which physics is taught as a science and an academic discipline. This concerns a wide field of communication between scientists and educators, philologists and teachers, and students of this level of education. The purpose of this study is to describe current trends in the development of semantic and terminological aspects of physics as a science and its teaching in English for higher education students. The research methodology is based on general scientific, general logical, etc. principles, in particular, on the principle of objectivity, the principle of historical-logical, the principle of comprehensiveness and complexity. The research methods reflect modern processes in the field of philology, linguistics, semantics (subdisciplines of linguistics), linguistics, etymology. This applies to physics as a science. The educational and pedagogical methods and approaches used in the study relate to modern methods and practices in the field of teaching physics as a science and academic discipline in higher education and postgraduate education. Of particular importance in this aspect is the bilingual approach, when higher education students communicate with teachers who are philologists, in general, scientific and pedagogical workers. As a result of the study, the following conclusions were made: 1. semantics and terminology are important aspects of dynamic processes that occur in physics as a result of significant social transformations, primarily in science, in the field of engineering and technology, in education, especially in its higher and postgraduate segment; 2. a new phenomenon in these gaps is physical semantics; 3. modern physics requires new approaches to its correlation with scientific, technical and technological innovations; 4. teaching physics in the system of higher and postgraduate education (philologists and linguists, physicists and engineers, teachers and educators) requires new approaches both in the bilingual philological and linguistic sphere in Ukraine and from the point of view of taking into account innovations in social engineering and technology. The latter is of strategic importance for the development of the defense sphere and the implementation of such innovations that should lead to the victory of Ukraine. The research prospects are outlined both in the field of philology, linguistics and linguistics, and in the system of higher and postgraduate education, which should take into account the current state of development of physics as a science and academic discipline, the participation of Ukrainian youth, on the one hand, in the development of domestic science, and on the other, in the prolonged process of integrating domestic science and education into the common cause of civilized democratic states opposing the neo-imperial encroachments of the hated enemy, in the process of implementing a modern technical and technological breakthrough in the military sphere.

Keywords: philology, linguistics, semantics, physical semantics, terminology, physical terminology (terms, concepts and categories), education, teaching, bilingualism.

1. Introduction

The rapid development of science and technology in the era of globalization and informatization, contributes to the spread of significant changes in all spheres of society, leads to an increase in the flow of scientific and technical information, the intensive dissemination of modern knowledge. In this regard, there is an urgent need to improve the system of information transmission and processing, prolonged transformations in the field of generation and dissemination of modern scientific knowledge, in particular, in the field of physics and its teaching in higher education. In these conditions, linguists are of great interest in the problems of professional terminology, the expansion of the boundaries of terminological systems, the growth of the role of terminological combinations, the increase in their specific weight: this is, in turn, connected with the differentiation and clarification of scientific concepts and categories. Linguists attach great importance to identifying the sources of the formation of scientific and technical terminology, the study of the regularities of the formation of terms, their structure and semantics, etc. The study of the terminology of a particular field of knowledge (in particular, physics) involves identifying specific forms of implementation of general and partial regularities of term formation and determining the possibilities of regulating the process of term formation, improving the terminological system of this field, etc. Semantics, as a subdiscipline of linguistics, is in a state of prolonged change, which is associated with many factors that are of decisive importance in linguistics.

This is of particular importance for teaching physics in English to those higher education students who are studying physics as a science for the first time in colleges and universities and who have not previously had experience of studying physics in English. In these areas, addressing the semantics of physical terms, concepts and categories in English specialized (professional) language has methodological significance in the sense of establishing optimal communication between physicists and teachers of English and the higher education students. This importance is enhanced by several factors: the importance of English as a lingua franca, including in the field of science and education; purely linguistic changes associated with factual and terminological innovations in physics in the 21st century, etc. These positions also apply to Ukraine, which has found itself in a state of complex geopolitical and sociocultural challenges threats and dangers. This is especially true for the further development of Ukrainian science and education.

Taking into account the above, we note the main components of the novelty of this study: 1. in the context of long-term social scientific and technological progress, significant transformations in the field of study and practical application of fundamental sciences, especially physics, the importance of theoretical and practical developments, primarily in the military sphere, acquires the status of strategic; 2. in Ukraine, the study of physics and its teaching in the higher education have an important signicance for social progress; in modern times, physics in Ukraine is of great, even strategic importance; a large number of scientists in this field either gave their lives for the sake of victory, or continue to work tirelessly in conditions of war on domestic territories; significant successes have been achieved by the physics community in universities of Ukraine; 3. teaching physics to Ukrainian students in English at different levels and in different aspects, in particular, philological-linguistic, has taken the form of a problem of bilingualism in our time.

2.Object and subject of research

The object of the article is physics as a science and an academic discipline in higher education institutions. Within the subject of research are analyzed the linguistic, semantic, and terminological structures within physics, examining how specialized terminology functions in both research and higher education. It explores the systematization of scientific terms, addressing communication, educational, ets. approaches, to language in physics higher education.

3. Purpose and objectives of the study

The aim of the article is to reveal the relationship between the semantic and terminological structures of professional English (physics) and the process of teaching physics as a scientific field and academic discipline in the higher education system, considered from a bilingual perspective. The first task of the study is to analyze the semantic and terminological system of the English language, considered from the perspective of studying physics as a science. The second objective of the study is the process of teaching physics as a science and academic discipline in the higher education system, in particular, in universities. The third task of the study is to consider the specifics of applying a bilingual approach to teaching physics as a science and subject in the conditions of Ukraine.

4. Analysis of literature.

Linguistic is the conventional meaning conveyed by the use of words, phrases and sentences of a language; lexical semantics is concerned with the meanings of words [1;2;3;4;5;6;7]. The history of semantics can be dated back to the writings of Plato and Aristotle. Later, in twentieth century, it reflects in the works of philosophers and logicians like Charles Peirce, Rudolf Carnap and Alfred Tarski, particularly under the heading of semiotics and the ‘philosophy of language’. From its inception in the 1880's through the 1950's, semantics dealt practically exclusively with word meaning. Since the 1960's, it has focused on sentence meaning. Semantics received proper attention since 1960’s when the structural semantics got more space into linguistics [2;3;4;5;6;7;9]. In philosophy of language (Gottlob Frege, Bertrand Russell, Ludwig Wittgenstein, the Vienna Circle, Willard Van Orman Quine, P. F. Strawson, John Searle, Robert Brandom) [10], semantics and reference are closely connected. Further related fields include philology, communication, and semiotics. In linguistics, semantics is the subfield that is devoted to the study of meaning, as inherent at the levels of words, phrases, sentences, and larger units of discourse (termed texts). Traditionally, semantics has included the study of sense and denotative reference, truth conditions, argument structure, thematic roles, discourse analysis, and the linkage of all of these to syntax [2; 5; 6; 7; 8; 9]. Based on research in historical semantics, Jost Trier introduced the term lexical field that he defined as a set of semantically related words whose meanings delimit each other [11].

In Ukraine, studies of semantics cover both linguistic aspects (word meanings, phraseology) and broader philosophical and logical issues. Various issues related to the interaction of languages, in particular the borrowing of vocabulary, have attracted the attention of many researchers, including Ukrainian ones. General theoretical issues were covered in their works by L. Bulakhovsky, V. Rusanivsky, K. Tsiluyko, V. Akulenko, A. Biletsky, Yu. Zhluktenko and others. Numerous lexical borrowings from individual source languages were analyzed in the studies of I. Sharovolsky, D.

Sheludko, A. Nepokupny, G. Ezhakevych, O. Rot, P. Lyzanets, A. Krytenko, O. Ponomarev, S. Hrytsenko and others. The problems of semasiology as lexical semantics in Ukraine have been studied and are being studied by Zh. Sokolovska, O. Taranenko, V. Manakin, V. Levytskyi, O. Selivanova, ets.

Highlighting the problems and prospects of using bilingual education in general secondary education and higher education institutions was carried out by I. Biletska, T. Bodnarchuk, I. Zozulya, K. Ignatenko, V. Gamanyuk and others, in particular, bilingual teaching of physics in higher education institutions (L. Bondarenko). Experts emphasize the need to introduce bilingual physics teaching: A. Husak [12], A. Kovalchuk [13], S. Lushchyn [14]. In particular, A. Husak, in co-authorship with A. Kovalchuk, developed a methodology for bilingual teaching of physics; it found its practical reflection in bilingual textbooks, manuals, scientific articles, etc. [12]. S. Sytnyakivska noted that one of the key characteristics of modern Ukrainian society is its globalization, and the main characteristic of the modern domestic social sphere is the dynamics of change, which requires an intensification of the search for new forms and methods, models, and technologies for organizing professional training of future specialists; that, since in these conditions the role of a foreign language in general and proficiency in a professional foreign language for specialists of a certain profession has increased, many domestic higher education institutions have begun to develop learning technologies that would allow students to study a foreign language of a specialized direction [15, c.83]. Important methodological material has been published in Ukraine [16]: "…Subordinate bilingualism occurs when the second language is learned on the basis of the first and continues to function on its basis (for example, when speaking or reading in a foreign language goes through internal translation from/to the native language) …" [16, c.33]. The article is interesting [17], it, in particular, states that, taking into account the fragmentation of academic circles of individual universities and research institutes, the difficult material condition of physics laboratories and physics classrooms in secondary education institutions and higher education institutions, the problem of training a highly qualified physics graduate who is able to work in a multicultural environment, present their own achievements and realize the opportunity to exchange knowledge and achievements with the global community of scientists (conferences, international periodicals, etc.) remains relevant [17, c.23]. Of particular importance for the development of this scientific problem are publications that describe the methodology of teaching physics to Ukrainian students in English. An example of this is the following publication [18].

Based on the above, we note that the development of bilingualism in the field of teaching physics as a science and academic discipline in universities has certain prospects in terms of developing new approaches in the field of linguistics, psycholinguistics, sociolinguistics, philosophy of education, and methodology for teaching physics at the level of modern forms and methods, including modern competency requirements for the use of English as a second language - both in Ukraine and at the international level.

5. Research methods

A comprehensive approach to research includes methods drawn from various subsystems of linguistics: 1. Lexical semantics methods; 2. Cognitive semantics methods, ets. Terminology as a science employs a systematic, multidisciplinary approach—combining linguistics, logic, and subject-field expertise—to analyze, create, and standardize technical vocabularies. Key methods include

descriptive analysis of term usage, terminological research (concept analysis), ets. The descriptive method allows us to analyze how terms are actually used in specialized literature (using the example of physics), scientific papers, and professional communication to map current usage. Bilingual linguistics methods involve techniques for teaching and researching language that utilize both the learner's native language (L1) and target language (L2) to facilitate understanding, such as the "sandwich technique" (translation-bridge-translation) and structured bilingual drills. Basic methods of teaching physics in higher education combine traditional lectures with active learning techniques to enhance understanding. Key approaches include interactive lecture demonstrations, peer instruction, just-in-time teaching, laboratory-based experiments (including virtual labs), and project-based learning. Studying physics in a bilingual environment is effectively achieved through communicative approaches using both languages (Ukrainian and English), visual aids, and specialized, multilingual materials. Key strategies include utilizing bilingual textbooks with parallel texts, implementing translanguaging (using both languages interchangeably), and focusing on experimental, hands-on learning to bridge language gaps with concrete physical phenomena.

6. Research results

6.1. There have been some attempts to design dictionaries according to semantic fields. For example, The English Duden: A pictorial dictionary (1960), was organized in 15 semantic fields, the first of which, Atom, universe and Earth are divided into such subfields as Atom, Atmosphere, Astronomy, Meteorology, and each section consisting of a numbered list linked to a picture with numbered elements. Semantic field more specifically is as a set of lexemes which covers a certain conceptual domain and which bear certain specifiable relations to one another [19;20].

6.2. The semantics of terms in the technical language of physics is distinguished by a high degree of accuracy, uniqueness and mathematical coherence [21]. The semantic way of forming terms from commonly used words is often based on their narrowing or use in a metaphorical sense. This occurs by analogy in function, form, purpose, process, quantitative characteristics, occurrence (origin), appearance, relationship of components and adjacency of concepts. Examples of terms in physics created in this way include the following: "work", "chain", «process», etc. With the rapid development of contemporary science and technology, physics, as one of the core disciplines of natural science, plays an important role in revealing the nature of the universe and matter.

6.3. Semantic physics, as a new discipline which integrates semantic mathematics and physics, came into being. It aims to build a more accurate and comprehensive physical theory system by deepening the semantic understanding of physical data [22]. Semantic physics aims to solve complex physical problems and promote scientific innovation through the framework of DIKWP model (data, information, knowledge, wisdom and purpose) [23]. Semantic physics has a wide range of applications, including cosmology, particle physics, quantum mechanics and thermodynamics, showing great potential. Semantic physics has a significant influence in the fields of education, scientific research, ets.

6.4. The "semantics of physical terms" can refer to two main concepts: the linguistic study of how meaning is conveyed by physical language or the physical interpretation of scientific terminology, where a term's meaning is linked to its role and significance within a physical system, often by a specific scientific theory or the information a system holds about its environment.

6.5. In the field of education, semantic physics can improve the way of physics learning and teaching. It makes it easier for students to understand abstract physical concepts through visualization and interactive tools. Educational software and virtual experiment platform can help students to carry out experiments and simulations, thus improving their learning effect. Semantic physics also helps to build more intelligent educational tools and carry out personalized teaching according to students' learning styles and needs. It will improve the way of physics learning and teaching, and make it easier for students to understand and apply physics knowledge.

6.7. Knowledge in the field of physics allows to find the correct interpretation without changing the very nature of the term. For example, the term "force" has the following translations: force, power (horsepower), strength (current strength), intensity (radiant intensity), amperage [24]. This linguistic concept focuses on words that describe the physical state of an object, in particular.

6.8. In physics, the term "physical meaning" refers to the significance of a physical quantity (e.g., pressure, temperature) within a particular thermodynamic or physical context. Some theories define semantic information as information a physical system possesses about its environment that is essential for its own existence and maintenance. It seeks to transform raw data into "information with clear semantics" and understand the essential nature of physical knowledge.

6.9. The vocabulary system of the specialized language of physics is constantly updated due to the use of various methods of forming new terms. In physics, terms are divided into main categories. The first group includes words that are typical terms in physics terminology, for example, "photon" or "atom". The second category includes ordinary words that are used in ordinary language, but in the context of physics acquire a special meaning, such as "wash" or "saturation". The third group is a word combination, in which complex words are created, which include names that are formed by combining independent words ("Electronvolt", "Force Field", "Photon Elements") or using a connecting vowel that unites dependent bases ("Light Interference", "Electron Spin", "Thermodynamic process".

Lexico-semantic term formation reflects the process of forming new terms by combining a word or part of a word with other lexical units in such a way that allows to convey a specific semantic meaning or specificity of the concept. This method is used to create new terms, which are often based on Greek or Latin roots (secondary nominative), as well as on combining words to create understandable and precise terminology. One example is the term "superconductor" in this case, "super" indicates properties that exceed the usual parameters, and "conductor" indicates the nature of the material that has these special properties. The bracketing is necessary to show that (Physical), for example, is associated with (Activity) and not, say, (Motion). Bierwisch (1969) has suggested that some of these features can be expressed by redundancy rules: “…For what could 'Fast' mean as a prediction of 'Motion' if not a qualification with respect to rate, or 'Physical' as a prediction of 'Activity' if not a qualification with respect to nature? " [25, cc.155-156].

Although most linguists nowadays accept that semantic features are not to be identified with their corresponding lexemes, one cannot avoid the suspicion that the semantic features are interpreted on the basis of the linguist's intuitive understanding of the meanings of the lexemes which he uses to label them [3, c.480]. However, the “conceptualist” or “mentalist' view of features is not essential in componential analysis. Semantic features may be regarded as theoretical constructs (which may be called 'concepts') postulated to simplify the description of the language, in particular, English, which has specific applications, for example, in teaching physics in English.

Brinton and Brinton [26, c.144] gives more examples of lexical field, in particular, water: A. water forms: ice, water, steam, sleet, rain, snow, hail; B. bodies of water: ditch, slough, swamp, narrows, strait, inlet, bight, bayou, brine, deep, firth, loch, tarn, well, reservoir, firth, pool, sea, ocean, lake, pond, bay, inlet, estuary, fjord, sound, gulf, lagoon, cove; C. water in motion: creek, river, waves, billows, stream, rain, brook, rivulet, tributary, spring; D. frozen water: ice, snow, crystal, sleet, hail, icicle, iceberg, rime, hoarfrost, glacier; E. gas: vapour, steam. This example is interesting from the point of view of applying semantic field theory to the visual representation of physical phenomena that are taught in physics courses.

Single-word terms are the foundation on which the terminological system of physics is built. They, as a rule, name basic concepts, are the names of primary concepts that have become fundamental in physics. The study of the grammatical structure of single-word English terms allows us to divide them into the main types: simple, affixal and complex terms. Simple terms that have only the root as a word-forming component include names such as quark, atom, beta, gas, carbon, ion, velocity and others. The most intensive replenishment of the terminological composition of a word occurs due to affixation, conversion, the formation of word combinations, etc., by adding left and right definitions to the original term, borrowing, reduction, a combination of several methods [27, c.150].

The formation of new complex one-word terms occurs through word compounding, when root morphemes are combined into one new term, for example, psi-meson, electromeson, electromagnet, switchboard. This way of forming new terms belongs to the least “problematic” ways of term formation, provided that the meaning of all the components of the new term is well known. In a separate group among complex one-word terms, words with international components are distinguished: -meter, hydro-,iso-, -graph, micro-, nano-, photo-, tele-, sub-, etc., also: isotherm, isotope, isospin, micrometer, telescope, nanotube, nanofiber, photodiode, galvanometer, voltmeter, microscope, subatomic, hydrocarbon [27, c.150].

One of the most productive ways of forming terms in physics is word combinations. These are unambiguous terms of narrow specialization, since they are used mainly in physics and usually do not have homonyms: alternating current, static friction, refractive index. Terminological word combinations have their own structural features, so they can be classified by lexical composition. Proper names are the basis of scientific and technical terms and are part of terminological phrases that are used to nominate specific objects, theorems, formulas, laws, measuring instruments, and help to specify a certain name. These are either derived terms or terminological phrases where the names are used in the genitive or possessive cases: Van der Waals force, Carnot cycle, Kelvin scale, Doppler effect, Dirac function, Avogadro number, Newton's law, Fourier optics, ets.

6.10. The semantic aspect of teaching English physical terms involves focusing on the meaning (semantics) of these terms by relating them to established semantic fields and using context-based learning methods. Techniques include grouping words into semantic fields, using visuals to represent abstract concepts, comparing English terms to those in the learners' native language to highlight differences and relationships, and building conceptual understanding through comparisons and analysis of synonyms, antonyms, and polysemous words within physical contexts.

This position also applies to the Ukrainian language, in which physics is taught in colleges and universities. This is especially evident in the use of ambiguous terms and concepts that are taught in Ukraine in English. This ambiguity in the interpretation of well-known concepts is caused by an important linguistic phenomenon - polysemy. The article by Marie-Claude L'Homme [28] states that

polysemy, even when considered in specialized fields (in particular, in physics), is a recurring phenomenon, can be interpreted from the point of view of linguistics and semantics as ambiguity, uncertainty, categorization or variability. In any case, polysemy is an integral part of specialized communication, various types of polysemy specific to a particular subject area are recorded. In particular, "specialized" polysemy, even if it decreases in specialized corpora and terminological resources compared to the polysemy described in general language resources and considered by lexicologists and lexicographers, appears to be an important phenomenon and manifests itself in various forms. Two forms of polysemy are important for the study – general and essential. In the general form, objective concepts have a mainly universal character, for example: "Universe", "matter", "space", "energy", "time", "motion", "rest", "development", etc. At the same time (if we interpret these concepts from the point of view of their essence) the essential polysemous form reflects the view on these concepts that have significance in various fields, including physics. In particular, the authors of the aforementioned publication interpret the concept of "field" in a certain way: «…At first sight, nothing seems to differentiate the meanings of the two occurrences of plant above ("to put vegetation in the soil for it to grow"); moreover, the argument structure remains the same (plant takes three arguments). However, each occurrence can be situated in different terminological networks…One network, more closely associated with the topic of agriculture, contains lexical units that express activities and objects that are involved in growing vegetation that will later be harvested to feed people and animals…" [28, c.216]. Another example is the polysemic interpretation of the concept of "activity": «…For instance, the GEMET Thesaurus does not record activity as a single-word term with two separate meanings in the field of environment: 1. "the natural movement of a natural entity" (e.g. volcanic activity); 2. "concrete actions carried out by humans" (e.g. industrial activity) …» [28, c.220]. We can add to this passage information about the "physical field" [29].

An interesting example of specified polysemy is the statement from the article by Yulia Tehlivets [30]: "… For example, the lexeme wave as a component of compound terms in the scientific terminological systems of the modern Ukrainian literary language is used in the meanings: 1) radio signal: traveling wave...; modulated wave...; return wave...; reflected wave...; spatial wave...; surface wave... " [30, c.13]. These provisions are in some way related to the process of teaching physics in higher education. For Ukrainian students who are taught physics as a science, including in English, it is important to understand these linguistic nuances - this will contribute to their deeper understanding of the interpretation of physics in the bilingual space - Ukrainian-English.

6.11. Historically, the study of physics is divided into three major stages: 1. Classical Physics; comprises the works developed by Copernicus, Galileo and Newton (for example, in Ancient Greece, Aristotle wrote what is considered now as the first textbook of physics; Aristotle's ideas were taught unchanged until the Late Middle Ages, when scientists started making discoveries that didn't fit them - Copernicus' discovery contradicted Aristotle's idea of an Earth-centric universe. Aristotle's ideas about motion weren't displaced until the end of the 17th century, when Newton published his ideas) ; 2. Modern Physics; set of theories that emerged at the beginning of the 20th century; 3. Contemporary Physics beginning at the end of the second world war whose main interest is subatomic particles [31, cc.201; 2502]. Thus, in general, Modern and Contemporary Physics emerges at the beginning of the 20th century to modify and complement the concepts of Classical Physics, starting with the hypothesis of Max Planck (of energy quantization) to solve the problem of the black body. In 1905, Albert Einstein published articles dealing with the photoelectric effect, the quantum of light, restricted

relativity and the Brownian movement. At the end of 1920 the theoretical structure of Modern Physics was completed with the works of Schrodinger, Broglie, Heisenberg and others [32].

In higher education institutions, the methodology of learning English for specific purposes (ESP) prevails - it involves the use of 20% of subject content and 80% of language content. The ESP methodology is aimed mainly at teaching a foreign language directly, while content aspects (in our case, this concerns physics) play a secondary role. CLIL has an ambivalent focus on both special content and a foreign language. At the same time, according to I. Salnyk, the combination of ESP and CLIL (more than ½ of subject content, with less language content) is the most optimal for the practice of teaching foreign languages in higher education institutions [33, c.31]. The last thesis is continued by C. Sytnyakivska: "…Bilingual education of "Canadian immersion" and "American absorption" became the basis of content and language integrated learning (Content and Language Integrated Learning – CLIL) … the term content and language integrated learning appeared in scientific circulation recently (in the late 90s of the last century), it was used to characterize bilingual education, in which education took place in two languages, with both the language and the educational subject being studied…» [34, c.90].

In philosophy and methodology of sciences, four educational paradigms have been successively alternating [35]. Within these paradigms, teaching Physics and experiments within it, has been interpreted in different ways. The rationalists base the methods of science on mathematical deduction, according to which the inevitable consequences are drawn from the most general cognitive truths applying an appropriate method. These consequences help us realize what reality is and what an illusion is. According to this paradigm, human spirit contains a set of privileged ideas and methods which help us draw other ideas. Therefore, for rationalists, experiment and experience are superfluous. Teaching strategies are the various techniques used to facilitate the education of students with different learning styles. The different teaching strategies are intended to help students develop critical thinking and engage with the material. The choice of teaching strategy depends on the concept being taught, and indeed on the interest of the students. Opposite to the rationalist paradigm, the empirical paradigm focuses on experience based on observation and experiment. The empiricists use the method of induction according to which the individual observation of environment leads to the range of broad generalizations, which again lead to the most general axioms. In that process, experience is not mere observation, susceptible to the tricks of our perception, but is based on systematic observation, comparison and verification [36].

The science and teaching of Physics in the 19th and the first half of the 20th century was based on the methods of induction and deduction; induction implying observation and experiment, deduction implying the creation of mathematical formalism. In the teaching practice, during the elementary education in sciences, this means conducting experiments exclusively for the purpose of observation and information gathering, followed by the formalization of knowledge. In this process, a student observing an experiment is a passive observer and knowledge recipient, who formalizes the knowledge having witnessed the experiment. This kind of experiment, the sole purpose of which is to observe and note a certain phenomenon is nowadays known as the traditional demonstration.

Constructivism, the contemporary paradigm in Physics teaching was formed in the 1980s, based on the empirical paradigm through CLISP (CLISP – Children's Learning in Science Project [35]) project, using the basic principles in the philosophy of T. Khun, K. Pooper and oth. Constructivism perceives a student as an active participant and analyst of the teaching process. Within this approach,

the role of demonstration changes methodologically and philosophically. In the constructivist demonstration a student is included in all ‘’scientific’’ stages and procedures of an experiment.

The notion ‘’scientific’’ encompasses all the procedures used by students, and which precede all scientific procedures, such as: observation, detecting, making hypothesis, experiment preparation, information gathering, information analysis, finding solutions and solution verification. An experiment created using such methodology, in which none of the research stages or students’ intellectual involvement has been omitted, points to better results in conceptual understanding of physical concepts, in recognition and correction of typical students’ misconceptions [37; 38].

The issue of semantic field should be dealt with in methodology classes at the English Language Teaching departments and when teacher trainees teach how to teach vocabulary and translation. If language learners are not aware of the problems and difficulties due to semantic field differences among culture, they may make language errors when using words in their sentences due to the semantic field differences between their own culture and the target language culture. Besides EFL/ESL course book writers should be aware of the semantic field theory and consider this issue when preparing methods of vocabulary teaching in their course books. Issue of semantic field is crucial for teaching vocabulary and translation [39].

6.12. S. Ivanenko notes that the main goal of bilingual education (which consists in combining professional and foreign language communicative competence) is the formation of bilingual professional communicative competence, which makes it appropriate to introduce bilingual foreign language training courses for professional purposes in various specialties, during the implementation of which two languages (Ukrainian and English) are a means of studying the content of a professional discipline (physics, in particular), taking into account the demands of the modern labor market for professionally mobile, communicatively competent and creatively thinking specialists [40].

A. Kovalchuk and A. Husak provided a number of recommendations regarding teaching physics in a bilingual educational environment: 1) in the process of bilingual teaching of physics, the following types of students' speech activity are distinguished: 1.1. reading and understanding: what is read (lecture notes, textbooks, physics manuals written by native English speakers); 1.2. listening and understanding what is heard (authentic audio and video recordings of physical experiments and other relevant information, teacher speech); 1.3. speaking (explanation of experiments, proof of theorems, support for the course of solving a problem, monological and dialogical speech in class); 1.4. writing (keeping lecture notes, written problem solving, reports on the performance of a laboratory experiment, etc.); 2) use of visual aids; 3) methodological support for the bilingual course should contain material and tasks aimed at implementing the types of activities; 4) it is recommended to introduce English grammar into the teaching of other activities; for example, students can be introduced to a new grammatical structure immediately before reading the text in which it occurs, and to practice and consolidate it in listening, speaking and writing tasks; 5) the acquisition of mathematical apparatus used in the study of physics should be carried out using exercises typical for the study and consolidation of any lexical material in English; in particular, it is recommended to introduce the dictionary at the beginning of each lesson; for convenience, it can be divided into mathematical, physical and general scientific components; 6) it is proposed to introduce the method of the so-called "language gradient" - a gradual increase in the share of English in the educational material; this applies only to lecture material, while further application and consolidation of the educational material occurs through exercises and during seminar, practical and laboratory classes; 7) teaching scientific communication in English; in this regard, it is proposed to include in bilingual

courses the development of skills for public speaking in English, making presentations, reports, oral everyday communication, writing business letters and other texts (especially scientific) of various types [12, c. 49-50].

7. Prospects for the development of the research

In the conditions of the development of the global information society, the society of modern information and knowledge, the importance of all aspects and approaches related to physics as a science and an academic discipline is of a strategic nature. This is especially true for Ukraine, its people, and young people who are studying. Knowledge of the English language and its practical application in various social and public spheres in our time is an important task for both experienced specialists and experts (scientists and teachers), and for applicants for higher and postgraduate education. Teaching physics in English in the system of higher and postgraduate education opens up new scientific and educational horizons, is of strategic importance in the period of building up the national defense potential and creating social and social conditions to ensure our Victory!

8. Conclusions

8.1. Semantics is a subdiscipline of linguistics. Lexical semantics is a section of semantics that studies the meanings of words. Semantics focuses on a specific language, in particular, English (it is the lingua franca of many branches of social knowledge and science, in particular). Semantics is closely related to etymology, which studies how words and their meanings have changed throughout history. This position also applies to physics, within which terms, concepts, and categories are continuously filled with new meaning. Dynamic semantics is a subfield of formal semantics that focuses on how information grows over time. This position also applies to physics and its English-language context (which is dynamic in nature), especially in the era of global informatization and digitalization. Cognitive semanticists study how the interaction between language and human cognition affects conceptual organization in very general domains such as space, time, cause and effect, and action. It is these concepts and linguistic objects that are the realm of applying knowledge and information from physics to its semantic-terminological fields. Physical semantics is an interdisciplinary field that reveals the features of cutting-edge subfields of fundamental physics. It is also directly related to the teaching of physics at the level of its modern achievements.

8.2. Physics, as an important natural science, will have a wider application in future society and require more talents in the field of physics. Physics teachers shoulder an important historical responsibility to enhance students' interest in learning physics and cultivate their core competencies in the field of physics. This requires physics teachers to constantly update their teaching methods and improve the efficiency of physics classrooms. There is still great room for exploration in the application strategies of teaching methods in physics teaching. Teachers should establish the concept of lifelong learning, keep up with social development, pay attention to the environment and cutting-edge technological trends in which students live, and truly become "learning oriented" teachers.

8.3. In the Ukrainian educational system, a bilingual approach to studying physics as a science and an academic discipline in colleges and universities is of strategic importance in several senses: first, educational and practical knowledge and skills in studying English should serve as ways for young people to become familiar with modern trends in the English-speaking world; second, teaching

physics in English in the Ukrainian-speaking educational environment has a multifaceted purpose: scientific, cultural and social; third, physics teachers, foreign language teachers in colleges and universities should constantly increase their scientific, pedagogical and educational and cultural potential in the direction of mastering the latest scientific and educational gaps, which are filled both with new content and forms, and are related to modern information, technical and technological innovations such as AI and mixed reality.

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