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A Practical Approach to ESP Teaching: English for Chemistry

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Abstract:

Professional fields require different corresponding materials for ESP teaching and learning. Since specific textbooks tailored for certain professions mainly exist for business, finance, tourism, and medical professionals and technicians, natural science ESP instructors must turn to the Internet, science textbooks in English, or the most challenging and inspiring way: in-house course material. Our English textbook for chemistry students has recently appeared in-house. The collaboration between English language teachers and the teachers of specialized chemistry subjects is essential, as their suggestions and corrections while gathering material and preparing the textbook are invaluable. This article outlines the foundational concepts in the creation of the textbook, the chemical domains covered, a theoretical and practical analysis of the needs of future chemistry professionals and offers several helpful examples of exercises charting the learning path from declarative knowledge to automation. We focused on all language skills – reading, writing, listening, and speaking. Given the acceleration of all human activities, the emphasis is on visualization and pictorial memory, analogies, and description using words from a minimal list that includes terms and processes – nouns, verbs, adjectives, and adverbs. Considerable importance is given to listening and comprehension using podcasts.

Keywords: ESP, chemistry, textbook, needs analysis, TBLT

Introduction

The world we live in is the world of 'Englishes', whether the focus is on main variants such as British and American or many others in countries where English is an official or second language. English for Specific Purposes (ESP) encompasses a broad spectrum of specialized English courses, including science, professional fields, and the arts. ESP, which focuses on what individuals learn rather than how they learn, has its roots in general English but has evolved to fulfil needs for specialized situations as the foundation for continued English learning development within professional fields.

However, for ESP to develop, it was also necessary for both linguistics and educational psychology to evolve in parallel, which indeed happened. Considering the phases of ESP development, various types of analysis emerged: register analysis, rhetorical or discourse analysis, target situation analysis, analysis of study skills and strategies, and analysis of learning needs (Hutchinson & Waters, 1987). ESP is thus defined as a learning-centered approach.

Register analysis involves identifying the specific language features and discipline-based vocabulary of different fields and establishing the unique linguistic characteristics of professional

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registers. Rhetorical or discourse analysis examines the use of language in relevant contexts, the structure of texts, and the types of discourse within a field. Since learners are likely to encounter various situations and have to perform tasks and functions in their professional environment, ESP practitioners must conduct a target situation analysis. Successful learning and application of ESP focuses on skills and strategies, from the simplest, like note-taking, to the most complex, such as effective communication. The final phase deals with analysis of learning needs, which involves tailoring the curriculum to meet the practical demands.

1. Needs Analysis

A couple of decades later, needs analysis, investigation of specialist discourse, and curriculum planning were still three important areas of ESP course design (Basturkmen, 2010). What ESP teachers focus on is teaching a specific language and developing communication skills. Thus, ESP course designers should start with the identification of the specialized 'technical' language and skills the group of language learners will need.

When discussing needs analysis, Brown points out that the initial problem is defining the term 'need' itself, depending on the subjects and context. He lists a multitude of meanings for this term: *wants, desires, necessities, lacks, gaps, expectations, motivations, deficiencies, requirements, requests, prerequisites, essentials, the next step, and x+1 (where x is what students already know, plus the next step, or 1*) (Brown, 2016). Specific standards have also been developed with the acceptance of a six-level scale of descriptors that specify the progressive mastery of each skill (A1 – C2), but these primarily pertain to general English.

The attitudes regarding needs analysis were based on 'target situation analysis' (Chambers, 1980) including communicative needs at the beginning and their realizations at the end. To get a thorough understanding of the 'needs', Dudley-Evans and St John (1998) offered their concept that included professional and personal information about the learners, their current skills and lacks, the goals, and how the course would be run. Since an ESP course should be established in a way of maximizing effectiveness, 'needs is actually an umbrella term' (Hyland, 2006, p. 73) embracing not only learners' backgrounds, goals, language proficiency, teaching, and learning preferences but also their reasons for taking an ESP course and their target communication skills.

In our opinion, the most significant aspect of needs analysis is – lacks. In other words, what is of utmost importance for ESP instructors is, indeed, present situation analysis (PSA) (Richterich & Chancerel, 1977), which draws attention to student's abilities at the beginning of the course and the gap between them and their needs at the end of it. Since most ESP teachers must resort to a one-size-fits-all approach, a challenging task for them is to identify the lack(s) of skills and knowledge and design a course and curriculum for all the students.

1.1. General English and ESP

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A distinction between English for Academic Purposes (EAP) and English for Occupational Purposes (EOP) was drawn by some authors (Flowerdew, 2013), with EAP most concentrated on writing and rooted in the EAP environment, while others, from the perspective of 'new vocationalism', discuss transferability from academic to professional context (Dovey, 2006). If we are to summarize the outcomes of EAP, it is the way of thinking that encompasses not only understanding and creativity but also the ability to criticize, compare, and evaluate. On the other hand, EOP and ESP deal with specific occupational features, and they are more vocationally and professionally oriented. Anyway, both EAP and EOP/ESP are gateways to somewhere – further education or employment. There is often a discrepancy between the language demands of the job and the academic skills required, such as listening, understanding, and writing, which recurs among employees at each promotional stage. Therefore, EAP can be viewed as an enhanced form of ESP.

In any case, spoken and written discourses should be considered when designing the curriculum and English textbook. Namely, in addition to writing reports on the progress of experiments or production processes, having a good command of speaking patterns is equally important for achieving effective communication in the workplace.

If we approach this differently and determine what is crucial in creating an ESP course and curriculum by defining the goals we want to achieve, for second and foreign language programs is vital to be well-motivated, well-designed, and successful (Long, 2015). Achieving this level means: needs analysis should be identified as an essential prerequisite for all three.

Naturally, it is implied that an ESP course has its purpose in establishing skills in specialized domains as an additional tool, and often a requirement, for performing a specific job. From the process perspective, it is a kind of upgrade based on general English, which, as a general-purpose course, is increasingly losing its purpose. Some authors doubt the sufficiency of skills within general English, claiming that 'off-the-peg, general-purpose language courses, sometimes known less flatteringly as languages for no, or nebulous, purposes (LNP) courses, are less and less likely to suffice, if they ever did' (Long, 2015, p. 99). However, on the other hand, there are opinions that ESP is 'educationally unsound' and that general-purpose courses are preferable because they offer education, not training, and broader language competence (Widdowson, 1983). What we could conclude considering both sides, is that a chemistry student will not be able to cope with the specific needs of their field and discipline-based content and context unless they have previously mastered the intermediate level of general English.

As we have already mentioned, the starting point for designing a teaching course for any subject, including English for chemistry students, is indicated in the needs analysis. A course designed in this way should ensure that students develop the ability to correctly and appropriately use both general and discipline-specific words and phrases, vocabulary, and grammar structures. In this process, the English language teacher must be guided by their insights and the necessary

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suggestions of the chemistry subjects' teachers. They should consider new possibilities for adapting and improving the teaching material and the teaching process based on long-term personal experience and the demands imposed by the modern world and its changes.

In the teaching of English for specific purposes, needs analysis is the cornerstone and the first step in designing the course curriculum, as well as the materials and textbooks that will be used in lectures and exercises. Therefore, a collaboration between specialists in professional fields and ESP teachers is inevitable and, of course, recommended when, after analyzing the profession-based needs, the requirements and specific standards for knowledge of specialist English are determined.

Since there is considerable flexibility and diversity in the specialized knowledge requirements imposed on students, as seen when comparing programs of different higher education institutions, the determination of language needs in ESP must consequently vary. However, it is essential to emphasize that, besides general English language knowledge, ESP teachers must also conduct independent research within the field their students are studying. They must establish a foundation, supporting pillars, and the scaffold upon which they will build the entire 'building'. They need to complete the process of identifying essential and less critical, but still necessary, knowledge and skills within the English language for specific purposes.

1.2. ESP Scaffolding Techniques

Using the terminology for identifying actors in designing the course of English for specific purposes, namely outsiders and insiders (Arias-Contreras & Moore, 2022), it is possible to analyze the needs in the field of chemistry from their points of view. Outsiders are those who are not experts in the field of chemistry, including English language teachers and first-year students. Insiders are experts in chemistry, whether they are teachers of chemistry subjects, employers, employees in various branches of the chemical or chemistry-based industries, or chemistry graduates. However, it is often necessary, not only in chemistry but in other fields as well, to resort to the so-called triangulation method. In this method, not only the actors – insiders and outsiders – are relevant, but also the place, time, interdisciplinarity, and perspective. This approach is crucial because views on the need for language proficiency in the field, here in chemistry, will differ between a manager in a chemical plant and the chief technologist/chemist. One is outside the field, while the other is within it. This difference will be more pronounced if the latter is required to interact with collaborators from abroad, as it will be necessary to consider cultural differences, which are often covered in ESL programs and reflected in ESP.

What does the phrase 'necessary professional knowledge' mean? To start teaching English for chemistry from the beginning, it will undoubtedly include the periodic table of elements, whose names and pronunciations can only be found in specialized dictionaries or online. A textbook for English for chemistry students should certainly contain a list of all the elements in the Mendeleev system, including orthographic variants in British and American English. Besides this

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list, students should also be provided with a reference glossary of chemical terms that should be periodically checked and updated, using the latest publications from IUPAC (the International Union of Pure and Applied Chemistry), such as new chemical elements. In 2016, the discovery of elements 113, 115, 117, and 118, respectively named *nihonium, moscovium*, *tennessine*, and *oganesson*, was announced, and students should learn about this not only in their chemistry courses but in English classes as well. Sometimes, their chemistry knowledge can be expanded based on facts presented in English classes, whether with the history of chemistry, anecdotes, fun facts, or similar.

In the design of teaching materials and textbooks, it is necessary to start with basic concepts (*atom, compound, periodic table, chemical bond, types of chemical reactions, experiment, laboratory,* and others) and then gradually get to a broader picture (*organic and inorganic chemistry, analytical chemistry, equipment in chemical laboratories, the Nobel Prize for achievements in the field of chemistry,* along with others). The final phase could cover various processing industries that apply chemistry (*food industry, textile production, rubber and lubricant manufacturing, petrochemicals, forensics, pharmaceutical industry,* and so forth) and environmental protection (*computational chemistry, green chemistry, and the rest*).

Dealing with the concepts, applications, and areas where chemistry is especially significant, and relying on the specialized knowledge students acquired in high school, the English language teacher will establish a feedback loop. The teacher will receive information from students from the field of chemistry and then expand their general English knowledge with specific terminology and structures needed for all types of communication in professional settings, from the chemistry laboratory to business. Thanks to their previously acquired general language knowledge, students can communicate effectively in specific areas using general vocabulary and descriptions.

2. Task-based Language Teaching

While learning a foreign language, students are faced with explicit learning and explicit instructions, which is a much more challenging way of learning compared to children under seven years old who learn unconsciously and without intention (more about skill-building or acquisition theories in Mitchell et al., 2019; VanPatten et al, 2020; Suzuki, 2024). Thus, it is the teacher's task to make this learning relatable to everyday life through familiar examples. Given that explicit learning is ’attention-driven, analytic-rational, efficient, short-lived, and transferable between different knowledge and skill domains’ (Li & DeKeyser, 2021, p.475), the teacher's mission is directed not only towards acquiring so-called declarative knowledge but also towards its proceduralization and automatization (DeKeyser in VanPatten et al., 2020). They adopt a system of sounds, grammatical rules, and semantic associations that make the starting point. Then, by repeating their learning practice, they reach automatization. For an English language teacher, what is essential is how to generate declarative knowledge efficiently.

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When discussing task-based language teaching (TBLT), the fundamental question is how the teacher perceives the concept of a task. For example, Bruton identifies nine types of tasks (2002), some of which can be considered general and applicable beyond language teaching (e.g., *problem-solving, decision-making, spontaneous role-playing; information/opinion gap resolution; cued prompted interaction*), while others are more focused on foreign language learning (e.g., *question-answer exchanges; prepared role plays; focused receptive language (+/- itemized); focused written language (+/- itemized) [reproduction]; understanding; and written expression*). The teacher's task, therefore, is to ensure a variety of tasks for students.

2.1. Inside a Chemistry Lab

When chronologically describing actions in performing an experiment and reviewing past tenses, the teacher's idea can be based on a chain of events followed by a series of comprehensive questions to check understanding. Alternatively, students might role-play an imaginary instructor-student interview to practice asking and answering questions. In this context, task-based language teaching should be considered a complement to, rather than a replacement for, traditional methods (Ellis, 2009).

While learning, students should be focused on solving specific tasks. For instance, learning vocabulary related to laboratory equipment involves applying the acquired terminology in a particular task. The vocabulary might initially be provided through a description or a picture, followed by a description of an experiment. Alternatively, an experiment familiar to the students based on their chemistry knowledge could be described first, with the meaning of new technical terms inferred from the context. A traditional practice in vocabulary teaching is to select a group of study words supposed to be gained over a definite period, followed by a test on spelling, definitions, and productive use in sentences (Nagy et al., 2012). Students show an inclination towards such a method of learning because it gradually and progressively increases in difficulty. They also prefer their workload to be placed within an established time context.

For chemistry English and occupational training, tasks based on real-world needs form the backbone of ESP activities in the classroom. Upon identifying difficulties, the teacher will adapt tasks to real needs by emphasizing the expanding of vocabulary, phrases, and sentence structures needed in a chemist's daily work. 'Learning by doing' can be applied here by demonstrating an experiment with an explanation in English, simple communication between students (e.g., *'Please pass me...,' 'Read from the instructions...,' 'Record the values obtained in...'*) or between the instructor and students (e.g., ***'What is H_2SO_4 in English?*** *'Sulfuric acid.'* ***'Are there other names?'*** *'Dihydrogen sulphate, oil of vitriol, matting acid.'* ***'Describe the acid using adjectives or phrases.'*** *'Colorless to brownish, strong, corrosive, oily, water-miscible, dense, dibasic, vigorous oxidizing agent, dehydrating agent, used in manufacturing batteries /dyes /paper /glue/ metals industries; present in volcanic gas; toxic fumes when heated.').*

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Students can also assign tasks to each other: describing a piece of equipment or a laboratory container (as mentioned above, the *Florence flask*) or guessing the name of an item based on its description (e.g., *'It is an item of lab glassware; it has a round body, a long neck, and most often a flat bottom; it is used as a container to hold liquids,* and so forth'). They might also describe a piece of equipment or a device (e.g., a *centrifuge*) or guess the object based on its description and function through given clues (e.g., *'It is a device; it separates fluids, gases, or liquids of different densities, sizes, or shapes under the influence of gravitational force; it contains a spinning vessel,* and the like'). Instructions for using glassware and devices in the lab can also be beneficial for learning technical vocabulary.

In this regard, of particular importance for students is to become thoroughly familiar with labels and warnings in the laboratory from day one. Since these are most often in English, the terminology associated with substances that pose a potential threat to human health should be taught and learned at the earliest stages (e.g., *dangerous, hazardous, fatal, toxic, self-heating, self-reactive, skin sensitizer, eye damage*). Terms whose meaning is inconsistent with what is expected (e.g., *flammable/inflammable/non-flammable*) must receive assiduous attention. In these situations, the significance of mastering technical English surpasses proficiency in general English, as a good command of technical English represents safety-related behavior that affects workplace safety. Understanding and correctly interpreting these terms can prevent accidents and ensure safe practices in the laboratory. Thus, integrating these safety-related terms into the curriculum is essential for the comprehensive education of chemistry students, aligning their language skills with practical and safety needs in their field.

When adopting this technical content, one can start with the most comprehensible items – visuals – information seen inside chemistry laboratories. Chemical substances inside chemistry laboratories must be stored in properly labelled containers. The mandatory information on these labels includes product name, signal word (*danger, warning, caution,* and similar), pictograms, hazard statement(s) (*irritant, flammable, corrosive,* and so on), precautionary statements, manufacturer name, address, and telephone number. In addition, information about safe storage, handling, use, disposal, and the supplier of the product must be provided. For most substances, the production or acquisition and expiration dates must also be indicated. From the first day of working in the chemistry laboratory, students must become familiar with labelling hazardous waste. Along with the product, manufacturers of chemical substances also send a document that contains detailed information about the physical and chemical properties of the product and emergency procedures (Safety Data Sheet), which also could make a substantial contribution to the 'technical vocabulary' in English.

2.2. In the classroom

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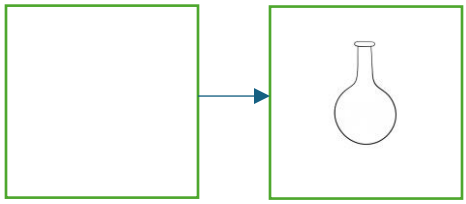
To encourage inductive chunk learning, the choice of appropriate pedagogical procedures is left to the teacher, who will be guided not only by their knowledge and experience but also by the knowledge and experience of their students. Many terms and phrases of chemistry English are very similar to those in Serbian (*element, atom, metal, oxide, experiment, laboratory,* and the like.), sometimes with similar orthography but noticeable differences in pronunciation, such as *covalent*: ENG: (kəʊˈveɪlənt) / SERB: (kovalentan); *monoxide*: ENG: (mənɒksaɪd) / SERB: (monoksid); *neutron*: ENG: (njuːtrɒn) / SERB: (neutron), and others. Furthermore, there are cases where internationally adopted symbols are more easily associated with Serbian names than with English ones (Na – ENG: sodium / SERB: natrijum; K – ENG: potassium / SERB: kalijum). It is also important to draw attention to the British and American variants, both in orthography (*sulphur/sulfur; analyse/analyze; vapour/vapor; per cent/percent,* and the like) and in pronunciation, e.g., *titanium*: (taɪˈteɪniəm)/(tɪˈteɪniəm), *ligand*: (ˈlɪgənd)/(ˈlaɪgənd), *ester*: (ˈestər)/(ˈestə), or *laboratory*: (ləˈbɒrətəri)/(ˈlæbrəˌtɔːri). Thus, learning technical vocabulary is not limited to merely acquiring new words, but attention must also be paid to orthography, phonology, morphology, and semantics.

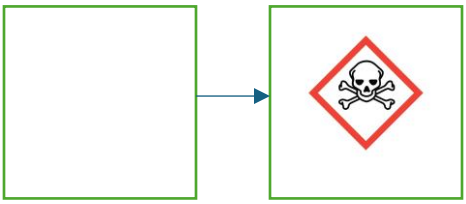
In addition, visuals can be not only practical but stimulating and entertaining in teaching English to chemistry students, whether in the textbook itself, in presentations, or suggested links on the Internet. For a change, students can be given the task of drawing a piece of laboratory equipment or one of the signs provided by the *Chemical Hazard Classification System*, with the terms and designators given through exercises in the textbook, such as:

Draw the following items:

a) Florence flask



b) Acute toxicity (pictogram)



Starting with mundane tasks that students can solve relatively easily, the instructor will guide them toward more complex and demanding ones. Sometimes tasks may seem simple, but practice has shown that students may find them challenging. For example, they might struggle when asked to give a simple description of *a container* (e.g., a Florence flask), *a pictogram* (e.g., a diamond-shaped distinctive red border and white background with a skull and crossbones inside), or *a piece of equipment* (e.g., an orbital shaker – a laboratory instrument used to mix or agitate samples in a container).

In addition to instructions for the use of containers, devices, and equipment in the chemistry laboratory, promotional materials from manufacturers and Internet advertisements for online

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sales can also be a good source of technical vocabulary that can additionally serve to practice general grammatical rules (word order in a sentence, parts of speech, passive voice, and the like), as well. We will use the example of a *Florence flask*:

***Description*:**

– The Florence flask is intended for uniform heating, boiling, distillation, and ease of swirling.

– It is available in a variety of glass thicknesses to accommodate various sorts of uses.

– Its narrow neck can be easily locked with a cork.

– The flask has a thin neck of 10 cm in total length with a beaded rim. The inner diameter of the flask neck is 44 mm, while the outer diameter measures 54 mm.

– Florence flasks are manufactured of high-quality GG17 borosilicate glass, which has a low coefficient of thermal expansion and can resist ordinary laboratory temperature changes.

For enriching professional vocabulary, an advantageous and enjoyable exercise is identifying synonym and antonym pairs of words and phrases, as in the following example based on the above description of a *Florence flask*:

Find synonyms for the following words or phrases:

swirling _____ (whirling)

cork _____ (stopper)

beaded rim _____ (flared lip)

manufactured of _____ (made from)

can resist _____ (capable of withstanding)

ordinary temperature changes _____(typical temperature variations)

It is intended _____ (It is designed)

It is available _____ (It comes; It is offered)

a variety of glass thicknesses _____(several different glass thicknesses)

accommodate various sorts of uses _____(suit different applications)

Student research assignments can also find their place here*: Who was the inventor of the Florence flask, and when was it invented?* (Some helpful tips can be passed on in advance, such

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as *the flat-bottomed Florence flask, produced by Kavalier Bohemia in Austria, believed to date from 1910-1930,* and so on.)

Visual presentations in acquiring technical vocabulary also represent an engaging way of learning words, whether it involves word families, collocations, examples based on analogies and associations, or the depiction of a complete chemical production process. It helps the teacher through the systematicity and consistency of teaching and in determining the extent of the vocabulary and the load of new technical words in the text. Speaking of families of technical words, when introducing a related word form, the teacher should primarily consider its frequency in a way similar to how the criteria of frequency, regularity, productivity, and predictability have found their place not only in teaching but also in general English for investigating lexical development and lexical storage, and in guiding dictionary making (Bauer & Nation, 1993).

2.4. Technical English and Vocabulary Lists

In creating word families, one can start by introducing affixes specific to chemical vocabulary, paying close attention to the vast technical vocabulary derived from Greek and Latin words. Since this 'technical English' is extensively used by scholars and specialists, it belongs to a small percentage of the population. But on the other hand, it has 'more of an international character than does ordinary English' (Nybakken, 1959, p.10). Over time, scientific terms based on Greek and Latin origins have become established and stable. Their roots, stems, and affixes are most often easily recognizable. Such words are common in chemistry vocabulary, and ESP teachers can help their students find the principles of word formation.

Besides morphology matters, a helping tool to teach and learn vocabulary can be word lists. A list of words prepared for high school students within several disciplines, including chemistry (Secondary School Vocabulary Lists), can be particularly advantageous in preparing them for tertiary-level education. Introducing these lists was based on developing specific discipline literacy, which is increasingly relevant to schooling in predominantly English-speaking countries (Green & Lambert, 2018). But they can also be worthwhile in ESP (English for Specific Purposes), e.g., chemistry. Moreover, this list does not exclude words already covered in the GSL – General Service List (Gilner, 2011), AWL – Academic Word List (Coxhead, 2000), UWL – University Word List (Xue & Nation, 1984), and AVL – Academic Vocabulary List (Gardner & Davies, 2014), and it compiles only the most common parts of speech – nouns, verbs, adjectives, and adverbs because of their high teachability. The SVL (Secondary School Vocabulary List) comprises three general types of word lists (lemmas, word families, and collocations). Since it is more based on lemmas than word families (Gardner & Davies, 2014), it leaves room for students to create their own word families and collocation dictionaries. The lemma list of the SVL presents 519 words for chemistry, beginning with the most frequent one – reaction. Among the first fifty words are most nouns, only three verbs (*form, react,* and *contain*), and only five adjectives (*chemical, aqueous, molecular, ionic,* and *strong*).

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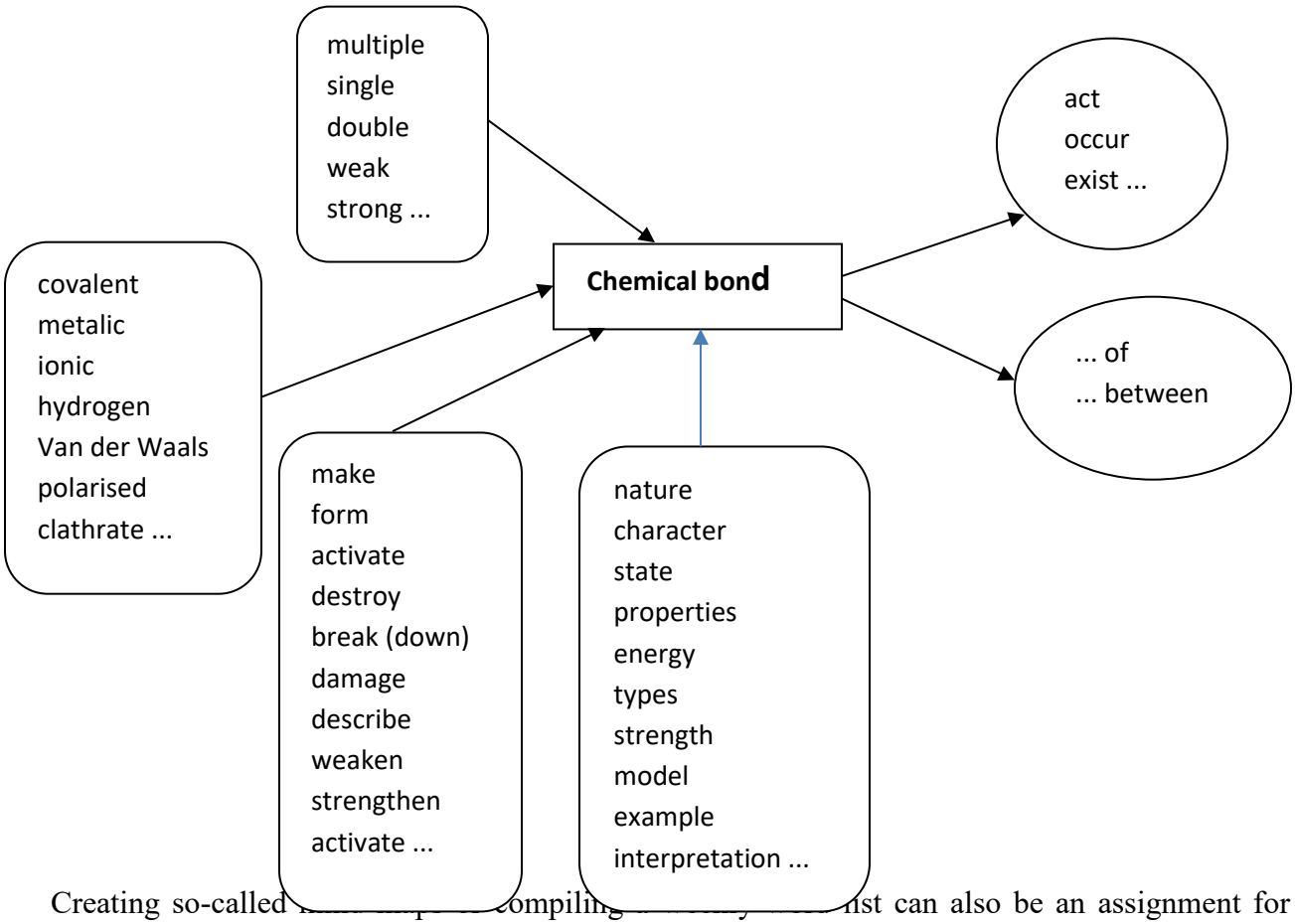
Although the attitudes towards word lists vary, all fruitful techniques should be welcome. That is especially true for ESP teachers who are expected not to work against their students' expectations. Although usual recommendations to teachers in their training courses are not compiling-friendly, lists are clear and concrete, and many students do like them (Folse, 2004). However, the type of word list affects the efficacy of vocabulary learning since some authors reported that the words in the categorical list were memorized more effectively than those in the thematic, arbitrary, synonyms, and antonyms lists (Hoshino, 2010).

2.5. Collocations and Visual Presentations

Since combining words within and between disciplines is not explicit enough, the standpoint that a word is primarily defined by the company it keeps (Firth, 1957) underscores the importance of collocations. Therefore, disciplinary-based collocations are challenging to chemistry students, and here we present just one of the possible ways to create a collocation map:

Figure 1



Creating so-called [illegible] compiling [illegible] list can also be an assignment for students, with or without provided clues. Thanks to the Internet and specialized dictionaries, students can complete complex tasks much sooner and find sentence examples for their

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collocation maps. Moreover, learning is not just tedious and fact-based; it is varied and engaging involving writing and visual presentation, which positively affects the retention of both words and collocations shifting from a rote learning practice to a meaningful learning pattern. Collocations are always context-based structures, and appropriate interpretation and productive use of vocabulary are closely related to collocations. Since contextual knowledge involves situational, topical, and local contexts, collocation is 'largely local context information provided by words in the immediate neighborhood of a word' (Nation, 2001, p. 71).

When possible and deemed appropriate to the teaching topic, ESP teachers should introduce situations that can be connected to everyday life. Analogies encountered help promote active thinking and linking of facts, as in the table below illustrating shape analogies between visual representations of results in a chemical experiment or series of experiments and corresponding shapes in everyday life. This task could also be presented as 'filling out a table'.

Table 1

Presenting results	Everyday life
bar graph	chocolate bar
pie chart	apple pie
spidergram	spider
flow chart	river flow
...	...

Also, biology-based associations can be engaged in chemistry teaching in two main ways. One is connecting chemistry with biological states and phases through nouns (*life, growth, development, decomposition,* and the like), life processes through verbs (*grow, branch, yield, crop, harvest,* and others), properties through adjectives (*organic, inorganic, natural, environmental, vital,* and so forth), and future inspiration (*biodiesel, green chemistry, biomimetic catalysis,* and the rest). The other way involves using visual tools in logically organizing data (such as *spidergrams* or *branching*), depicting causes and effects over time, or starting from a central part and essence (core) — whether it is the nucleus of a chemical element atom or a living cell. Here is an example of a spidergram illustrating the personal protective equipment needed in a chemical laboratory:

Figure 2

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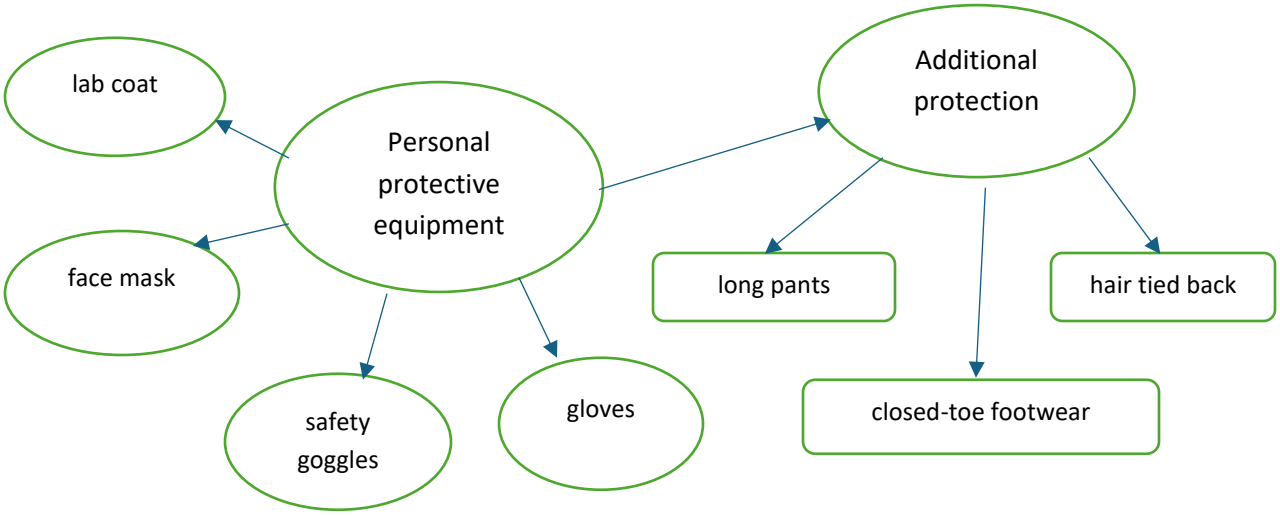
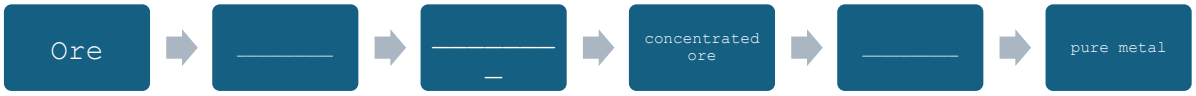


Chemical processes, whether individual chemical reactions or complete processes, can be represented in various ways: through chemical equations sometimes and occasionally using scales, flowcharts, bar graphs, scatter plots, histograms, and others. These presentations, along with commonly used visual aids such as tables, pie charts, and 3D models, should be introduced to students in their English for chemistry course. This way, they can simultaneously learn academic terminology and mentally connect it with the visuals.

One such visual tool is a flowchart, which represents a process workflow or the sequence of steps. Flowcharts and flow diagrams are tools used, for instance, to depict the development of a process in the industry, from the initial raw materials through a series of chemical reactions and physical changes to the final product. A flowchart can also be an exercise in filling in the blanks, i.e., writing in words that relate to specific parts of the process.

Figure 3



In the flowchart above, students are presented with the words *ore* and *pulverized ore.* They are supposed to connect the steps of the flowchart with the processes – *crushing, grinding, pulverization, froth flotation, leaching, roasting, calcination, reduction, electrorefining,* and others. ESP instructors can use associations and pantomime connected to everyday life to enhance students' understanding and retention of technical terms related to chemical processes. For example, *crush* can be associated with crushing a Coca-Cola can or garlic, and *grind* can relate to fresh ground coffee. Alongside the flowchart exercise, a supplementary table can be prepared where some fields are left for students to fill in.

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Table 2

Term	Collocation	Synonym
crush	can/garlic/package	press hard/smash/squash
grind	coffee/pepper/corn	mill/mince/grate
pulverization	bran/raw material	making powder of
froth	beer/detergent	foam/lather
flotation	froth flotation	ore separation
leach	of chemicals/from the soil	percolate/filter/strip
roast	ore/meat	heat
calcination	limestone/temperature	oxidation by heating
reduction	metal oxide	reverse oxidation
electrorefining	copper/nickel/tin	purifying by electrolytic cell

As previously mentioned, any English text that students encounter in a chemistry laboratory can serve as textual material. That includes labels on containers of various substances, printed equipment usage instructions, promotional materials from manufacturers, and technical documentation on procedures and protocols. Besides passive use of English (reading), students should also be encouraged to use it actively (writing, oral, and written communication).

2.6. Presentations and Podcasts – Out of the Box

Every year, at the beginning of a semester, a comprehensive list comprising chemistry topics is generated, from which students should choose one. In pairs, they prepare a presentation they will deliver in the classroom as a short lecture accompanied by a PowerPoint or similar format video presentation. All student presentations are downloaded to an online platform to be accessible to everyone whenever needed. Students are encouraged to use not only Internet sources but also printed books from libraries, which are often unjustly neglected. A successful presentation is well-structured and delivered with clarity and fluency to the audience of other students. A pleasant surprise is a presenter who gives their presentation effortlessly, with stress and intonation conveying finer shades of meaning. At the top of the scale is the ability to handle questions – from straightforward to follow-up and a high level of questioning.

Using podcasts in line with podcast-based exercises can be done in the classroom as collectively solving tasks or through independent work at home. Thanks to the Internet, there are numerous short podcasts available in the field of natural sciences, particularly chemistry, which can be found on various links such as https://player.fm/featured/chemistry, https://cen.acs.org/sections/stereochemistry-podcast.html, https://bringing-chemistry-to-life.simplecast.com/, https://chemforyourlife.transistor.fm/, and others. These podcasts cover a wide range of topics and can be interesting even to lay people, such as why metals look metallic,

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what cheese and soap have in common, the chemistry of onion tears, how purple shampoo works, and many more.

Podcasts are excellent material not only for listening comprehension exercises but also for practicing pronunciation. They can be paused, replayed multiple times, and used as a basis for role-play. To start with the simplest, students can summarize the main points of the podcast in writing or orally. They also can record themselves and compare their pronunciation with the podcast. They can role-play a scenario related to the podcast they have listened to using key vocabulary and phrases. Also, they can write a brief report or reflection on the podcast episode. The most curious could find additional resources and related content. By incorporating podcasts into the curriculum, students can not only improve their listening skills, but they can expand their vocabulary, enhance their pronunciation, and engage more deeply with the content through interactive and practical activities.

However, ESP teachers have an additional role – to make English classes not only productive in terms of processing novel language information but also to maintain the interest level of their students by introducing elements of fun, such as crossword puzzles with chemical terms, bingo with chemical elements instead of numbers, or mnemonics like these:

- **Oil Rig**: **O**xidation **i**s **l**oss; **R**eduction **i**s **g**ain (of electrons).

- **H**ave **N**o **F**ear **o**f **I**ce-**C**old **B**eer. (molecules exhibiting diatomic structures: H, N, F, O, I, Ch, Br)

- **Chopin's café:** (the elements comprising the human body: C, H, O, P, I, N, S, Ca, Fe)

Finally, while the ESP course for chemistry students is heavily discipline-based, preparing a good CV and job interview skills will be crucial for graduates in finding their first job alongside their degree. In this context, teaching English to future chemists focuses on general language knowledge as a foundation, then expanding it with academic and specialized vocabulary and its practical application as the primary and paramount goal.

Conclusion

The essence of ESP teaching is to ensure that students from various fields master the English language, especially their profession-related vocabulary and collocations, and help boost their professional language competence. In teaching English to chemistry students, we consider what is novel for them and what they need in their job performance, collaboration with colleagues, and using English literature for those who want to improve their skills or prepare for further professional development. This is particularly important since only a few chemistry students choose to work as chemistry teachers after graduation.

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Here, we tried to emphasize the importance of well-identified needs at the beginning of the design of the English for Chemistry course and the continuous follow-up of students' performance and achievement to measure the outcomes of the course. A well-designed textbook is half of the success but, with the absolute acceleration of life affecting the same pace in education, novel material for ESP classes should be accordingly prepared. Both teaching and learning must be as much encouraging as fun and enjoyable – a challenge for both teachers and learners.

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