ELeFyS: A Greek Illustrated Science Dictionary for School

***Maria Mitsiaki*[1], *Ioannis Lefkos*[2]**
[1]*Democritus University of Thrace,* [2]*University of Macedonia*
E-mail: mmitsiaki@helit.duth.gr, lefkos@uom.edu.gr

Abstract

This paper reports on the design and compilation of ELeFyS (Εικονογραφημένο Λεξικό Φυσικής για το Σχολείο, ΕΛεΦυΣ), a Greek specialized school dictionary of science. Since its conception ELeFyS has been intended as a reference tool for the parallel development of scientific and linguistic literacy in a school context. To fulfil such an objective, generic entries include scientific terms that fall within the school subject of physics and are likely to be encountered in the upper grades of primary and lower grades of secondary school; however, the dictionary coverage is not restricted to terminology, but is also expanded to the terms/headwords' respective general sense(s) and use(s). Moreover, encyclopedic and cultural material is given as further stimuli for critical thinking. Under this scope, ELeFyS works both as a lexicographic product and a multi-functional teaching resource. In sum, it constitutes a novel endeavor of combining pedagogy and specialization in order to meet the complex linguistic and cognitive/scientific needs of school children in the late primary and the early secondary school grades. Such a complex aim of determining both communication- and knowledge-oriented lexicographic functions is being realized thanks to the enduring collaboration of a linguist and a science expert, well-rooted in long teaching experience. In what follows, we focus on the policy decisions made at the outset of the lexicographic project and the entry-building process.

Keywords: Greek science dictionary, macro- and microstructure, content-based learning/instruction

1 Introduction

It is only recently that the Greek school community has embraced dictionary use, setting the basis for the establishment of a dictionary culture. The first pedagogical dictionaries were introduced into the Greek educational system as schoolbooks about 15 years ago (Antypa et al. 2006; Gavrilidou et al. 2008, among others), despite the fact that linguists had emphasized the need to initiate a school practice of dictionary use since the 1990s (Anastassiadis-Symeonidis 1997; Iordanidou & Mantzari 2004). Our lexicographic endeavor attempts to resituate the pedagogical dimension of dictionary use, by providing intensive opportunities to integrate a specialized dictionary into the school learning process.[1]

ELeFyS innovates in several aspects. Namely, it is:

- the first specialized science dictionary that has been compiled in Greece in order to foster content-based learning/instruction both in L1 and in L2, thus promoting reception and production of scientific terms and their respective use in general language
- a pedagogical dictionary intended to cover the specific cognitive, encyclopedic, linguistic and cultural needs of school children with respect to science, as they arise in various types of learning situations
- a monolingual dictionary, which establishes interlingual equivalence of scientific terms in five languages, thus being a useful reference tool for L2 learning in academic contexts
- an illustrated dictionary, as it provides visual tools represented by images and animation with

1 Such an integration is more urgent nowadays, since most primary education curricula aim at (1) raising awareness of the relevance of science with regard to environmental and social concerns, and (2) promoting learning through inquiry (Harlen & Qualter 2014).

sound effects for the scientific terms and processes they entail, but also for the general word meanings, and finally

- an electronic dictionary freely accessible on the Internet (www.elefys.gr), as it delivers the dictionary data via the use of digital media, thus circumventing the common dictionary conventions in terms of space limitation, and making imaginative use of new technology in order to ensure flexibility, user-friendliness, and a pedagogy-oriented format.

2 Theoretical Grounding: Lexicography and Scientific Literacy

ELeFyS draws on a wide range of theoretical inputs, so as reliance on intuition is kept to a minimum. As a monolingual dictionary it is firmly-grounded on lexicographic theory, taking into consideration the seminal works of Mel'čuk (1996), Rosch (1973), Lakoff (1987), and Geeraerts (1990) among others for lexical functions, prototypes and definition writing respectively; it is also informed by the latest trends in lexicographic practice (Rundell 2006; Atkins & Rundell 2008; Rundell 2012), especially regarding the use of digital media for delivering lexicographic data. As a pedagogical dictionary (Tarp & Gouws 2012) it takes into consideration the perceived cognitive and linguistic –academic and communicative – needs of first and second language learners in the late primary and early secondary school grades.[2] As a pedagogical specialized dictionary (see also Tarp 2005), it attempts to initiate young learners into the academic language of science, following though a more broad-brush treatment of the different senses and uses, considered to be suitable for the targeted user group (school children who are 10-13 years old). No further reference to theoretical lexicographic insights will be made at this point, as the team's decisions are justified on a theoretical basis both for macro- and microstructure in Section 3.

However, it should be mentioned that ELeFyS is also consistent with the well-established body of theory (see e.g. Driver et al. 1996; De Boer 2000; Osborne 2002; Plakitsi 2010) underpinning the importance of scientific literacy as a transferable outcome of science education. Although many educators advocate the naive belief that science is equivalent to empirical work in the laboratory and that scientific language is simple and unambiguous (Lemke 1990), scientific literacy is a far more complex concept, closely related to knowledge, linguistic performance, argumentation, cultural identity, and so on, presupposing that school children are able to communicate science and the language of science. In most cases, the learners' difficulties in understanding science are attributed to the complexity of its terms or concepts (Shayer & Adey 1981), a consideration which is partly valid, as it holds true for polysemy, an inherent property of language. Polysemy undoubtedly imposes an additional conceptual load, since terms are very often used with different meanings in general language, e.g. *κύκλωμα* "circuit", *δύναμη* "force", *ενέργεια* "energy". Nevertheless, the difficulties encountered by learners in scientific language should also be traced to:

- contextual parameters
- the multi-semiotic practice of science
- the nature of its genres (Halliday 2004)
- the structural features of scientific discourse.

In particular, a word's precise meaning can only be determined by examining the context of its use, a process which requires learners to acquire skills of recontextualization, e.g. the term *ηλεκτρισμός* "electricity" could refer to various interconnected but different concepts, such as *ηλεκτρικό φορτίο* "electric charge", *ηλεκτρική τάση* "electric voltage" or *ηλεκτρικό ρεύμα* "electric current" (Osborne 2002: 209). In addition, the multi-semiotic nature of science may hinder progress with regard to

2 The term "pedagogical dictionary" is used in its broader sense, being targeted both to native and second/foreign language learners (Dolezal & McCreary 1999).

achievement in this subject. For instance, energy can be multi-dimensionally represented as a symbol (E), a diagram or a mathematical equation, a complex definition and so on. Scientific language is also impersonal, objective and distant, reflecting the description of physical phenomena through the eyes of an independent observer, making use of inquiry, report, explanation and argumentation. Moreover, it is cumulative, since each argumentation in any given scientific domain builds on ones that have gone before (Osborne 2002). Finally, it exhibits complex characteristics and structures, such as:

- lexical density, e.g. *άτομο* "atom", *μόριο* "molecule", *χημική ένωση* "chemical compound"
- high or +learned register, e.g. *ασκώ έλξη* "pull/attract" vs *νιώθω έλξη* "feel attracted"
- passive constructions, e.g. *το φως διαθλάται* "the light is refracted"
- extended use of subordinate clauses, e.g. *μαγνήτης είναι το σώμα που έχει την ιδιότητα να έλκει αντικείμενα από σίδηρο και ορισμένα άλλα μέταλλα* "a magnet is an object that has the property of attracting iron-containing objects and other metals"
- taxonomies, e.g. *υποατομικά σωματίδια: ηλεκτρόνια, πρωτόνια, νετρόνια* "subatomic particles: electrons, protons, neutrons"
- abstraction, e.g. *ύλη* "matter", *ενέργεια* "energy", *δύναμη* "force"
- nominalization, e.g. *η διάθλαση του φωτός* "the refraction of light", etc. (see also Arapopoulou & Giannoulopoulou 2001; Anastassiadis-Symeonidis et al. 2014).

In this respect, "every science lesson is a language lesson" (Wellington & Osborne 2001: 2).

ELeFyS attempts to capture, codify and resolve the aforementioned inherent difficulties of the language of science by combining cognitive, linguistic, encyclopedic and usage information. Furthermore, its structure contributes to the term/general word recontextualization by exposing learners to numerous illustrative and illustrated examples. Finally, from a critical point of view, the information and prompts included function as stimuli for experimentation, reasoning and argumentation. This way, it serves a dual function as a dictionary and as an educational resource, which can be utilized for the application of innovative teaching approaches to science, making scientific content comprehensible to native, second language or foreign learners and portraying the similarities and differences between the scientific and general use of words. Needless to say that the comparative presentation of the words' scientific and everyday meanings and uses facilitates the interconnectedness of scientific and linguistic literacy, which, in turn, opens the way for interactive approaches that "safeguard the subject being taught whilst promoting language as a medium for learning" (Coyle in Marsh 2002: 27), such as CLIL and content-based instruction.

3 ELeFyS: Design Principles and Description

3.1 Macrostructure: Policy Decisions

3.1.1 User Profile, Headword Selection and Resources for Entry-building

The user profile crucially affects the selection and presentation of the lexicographic information included in the dictionary, and drives the specific editorial decisions made with respect to its content and form (Atkins & Rundell 2008). ELeFyS exhibits the following range of potential users and uses. Firstly, it addresses the needs of children – native Greek speakers or second/foreign language speakers – in the school setting. Secondly, it caters for several types of uses that target the school children's receptive and productive skills, such as:

- studying the science school subject (i.e. understanding the scientific discourse, producing oral or written argumentation, reports, essays, etc., preparing for a written or oral exam)
- general reference purposes (understanding unfamiliar lexical items, distinguishing words in

general language from terms, finding information on word families, grammar, usage, etc.), and
- learning the Greek language and acquiring not only communicative but also academic skills.

As a result, the way that information is selected and presented is largely determined by what we know about the users' skills and knowledge. More specifically, 10-13 year-old school children – both native speakers and second language learners – are 'quasi-proficient' in the school language, as they have to face the discontinuity between the conversational focus of the primary Greek curriculum and the academic focus of Greek as a medium of instruction in secondary school (see also Cummins & Yee-Fun 2007). Such a difference between 'surface fluency' and cognitively-related skills calls for lexicographic decisions that aim at both communicative and academic competence or/and performance. This means that students in the late primary and early secondary school grades are in need of a different configuration of lexicographic facts, which makes use of pedagogical prompts establishing a learning environment of creativity and enjoyment, as well as of academically-related stimuli enhancing cognitive achievement and motivation. Under this scope, in compiling ELeFyS we opted for the more broad-brush treatment of terminology and the incorporation of a limited amount of scientific information, without, of course, misrepresenting scientific theory or violating its principles. Additionally, we adopted numerous pedagogy-oriented strategies, such as:

- substitution of metalanguage and abbreviations by lexicographic symbols
- illustration of terms and general-use words
- alternative wording of definitions
- a wealth of examples
- prioritization of word meanings
- appropriate grammatical and usage information
- translation of terms in five languages
- recorded pronunciation, etc.

On the other hand, in order to initiate students into academic discourse, we favored components such as:

- gradation of term definitions in terms of difficulty
- etymological information
- a manageable number of informative examples showing the lemma in use in its various meanings and patterns (e.g. nominalization, passive construction, subordination, etc.) and grounding the scientific theory to direct experience of physical phenomena, and
- notes/prompts for experimentation, further scientific study and critical thinking.

In order to decide about ELeFyS's coverage, we based our work on the following resources:

- the Glossary that accompanies each section of the Greek science school textbooks
- the online 2-million-word Greek School Textbook Corpus (from the Center for the Greek Language website), and
- the headword list included in equivalent dictionaries of other languages (e.g. the *Oxford Primary Illustrated Science Dictionary* and the *Oxford Student's Science Dictionary*).

Recourse to such resources is justified by the targeted user group and its needs; since the dictionary entries reflect the combinatorial behavior of scientific terms and their respective use in general language, school language corpora should provide the basis for headword selection.[3] Moreover, the terms' conceptual opaqueness and their semantic inclusiveness were introduced as additional lemmatization criteria. For instance, despite its centrality and wide coverage in the language of Science, the meaning of the term *ύλη* "matter" is rather fuzzy and thus not easily conceivable by young learners;

3 Unfortunately, no extensive corpora of school discourse are available at the moment for the Greek language. The sample of classroom interaction data that is included in the Corpus of Spoken Greek is not representative of the language of science.

therefore, the term was included in the headword list. In such a way, less-frequent words denoting peripheral scientific concepts were excluded from the lemmatization process. For instance, the term *εξάχνωση* "sublimation" exhibits only five occurrences in the corpus (mostly in high school science textbooks), whereas the term *εξάτμιση* "evaporation" exhibits 65 occurrences (displaying an equal distribution in primary, secondary and high school textbooks). In sum, ELeFyS attempts to reflect and 'ease' the phenomenon of nominalization apparent in the language of science by lemmatizing noun terms characterized by abstraction or/and denoting processes, e.g. *άπωση* "repulsion" instead of *απωθώ* "to repel".

3.1.2 Layout, Constituent Parts & Medium

The dictionary entries are arranged according to their semantic interconnectedness (see also Bowker 2003). Such an arrangement led to the grouping of terms into broader thematic fields, i.e. Properties of Matter & Atomic Structure, Heat & Temperature, Electricity, Energy, etc., which is also supported by the Greek science textbooks.[4] However, all lemmas that fall within a specific subfield are arranged in alphabetical order, e.g. *άτομο* "atom", *μάζα* "mass", *μόριο* "molecule" in the subfield "Properties of Matter & Atomic Structure".

As a specialized dictionary of science, ELeFyS contains compiled information which is partly scientific, but also partly linguistic for the same lexical unit.[5] That is why each dictionary page corresponds to a distinct multi-lemma (see Figure 1), i.e. an entry that encompasses other morphologically and semantically-related lexical units.

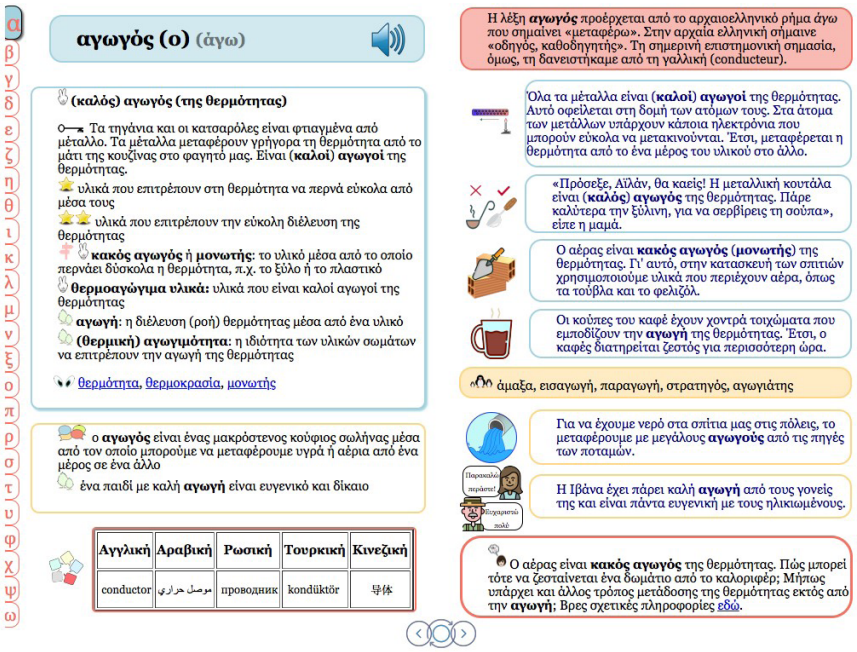

Figure 1: A dictionary page, the lemma ἀγωγός "conductor".

The dictionary front matter contains a foreword (for the teachers but also for the students) and an explanation of labels/symbols used in the text. The Teacher's Foreword is based on ELeFys's Style Guide, the document that sets out in detail the way in which the dictionary entries are written. The

4 As teachers, we consider such an arrangement to be helpful for the integration of a specialized dictionary into classroom practice.

5 Of course, the boundary between terms and words is not always clear-cut; concepts that may have once been part of a highly specialized domain may filter down into our everyday lives, e.g. *(φυσικό) αέριο* "(natural) gas" (de-terminologization, Meyer & Mackintosh 2000 from Bowker 2003).

use of lexicographic symbols instead of abbreviations and metalanguage ensures the pedagogical role of ELeFyS; each symbol was selected on the grounds of its pictorial transparency, i.e. a penguin family is used to denote the word family notes and a two-finger hand gesture is used for multi-word compounds. All of the lexicographic symbols are explained immediately after the Teacher's and Student's Forewords.

Its digital format frees ELeFyS from the constraints of traditional printed dictionaries, such as space limitation and navigational difficulties. In terms of space, though, we do not plan to 'swamp' the user with lexicographic data just because we can (see also de Schryver 2003). On the contrary, following Lew (2012) we give special emphasis to the 'presentation space', by taking into account how much information the targeted user can process; thus, one of our main design principles was to maintain a double-column page-like layout for every lemma, in an effort to accomplish a holistic single-glance overview of the information. Navigation through the dictionary can be achieved in various ways. Primarily, it is facilitated by an interactive alphabet marker on the left side of the lemma page, graphically resembling a printed dictionary alphabet marker. Every letter is linked to the corresponding alphabetized index page at the end of the dictionary. Additionally, there are hypertext links which allow cross-references to other lemmas and navigation buttons for quick transition to neighboring pages or scientific subfields.

The interactive web-based format leads to further benefits, i.e. ease of access from anywhere through an internet connection inside and outside the school classroom, ease of navigation, multimedia content, such as animated illustrations and lemma pronunciation, around-the-clock debugging and updating, page printing, etc. From a technical point of view, ELeFyS was compiled on specialized software for creating multimedia e-books with built-in interactivity, offering the capability of publication to a number of different digital formats, like web-based (as in our case) or e-reader (epub3) format or mobile phone app.

So far the first edition of ELeFyS contains about 200 lemmas and sub-lemmas, a figure not to be 'sneezed at', considering its pedagogical dimension and specialization, and its intended user group and purpose. However, the compilation of an electronic dictionary is a dynamic process; thus, more lemmas are about to be added in the future and any potential technical problems will be resolved in the next edition.

3.1.3 Entry Components and Lexicographic Information Distribution

Within the broad scope of an entry, there are three principal components that carry additional information, related, though, to the main lemma: (1) sub-lemmas, (2) multi-word expressions and (3) run-ons. To start with, decisions were made concerning both the assignment of a main lemma status to the various items and the distinction between main lemmas and sub-lemmas. Both the entry components and distribution of lexicographic information analyzed below is portrayed in the template entry (Figure 2). Specifically, lexical items that are related to the entry either morphologically (derivatives, compounds or multi-word compounds) or semantically (hyponyms, meronyms) are entered as sub-lemmas under a particular headword. In any case, sub-lemmas are not granted their status arbitrarily, but they are directly associated with the main lemma (either a term or a general-use word). In such a way, multi-lemmas are formed combining interrelated linguistic information. For instance, the main entry *μαγνήτης* "magnet" includes the sub-lemmas *μαγνητικός* "magnetic" (derivative), *μαγνητικό πεδίο* "magnetic field" (multi-word compound), and *ηλεκτρομαγνήτης* "electromagnet" (compound), whereas the main entry *άτομο* "atom" includes the sub-lemma *πυρήνας* "nucleus" (meronym). Multi-word items are a central part of the Greek scientific and general-use language (Anastassiadis-Symeonidis 1986; Anastassiadis & Efthymiou 2007, Tantos et al. 2016). Despite their

fluid boundaries and the acknowledged difficulty in establishing robust criteria for their lemmatization (Cowie 1994; Mel'čuk 1998), multi-word items are given a specific treatment by being classified into two broad categories: (1) (semi)fixed phrases and (2) multi-word compounds.

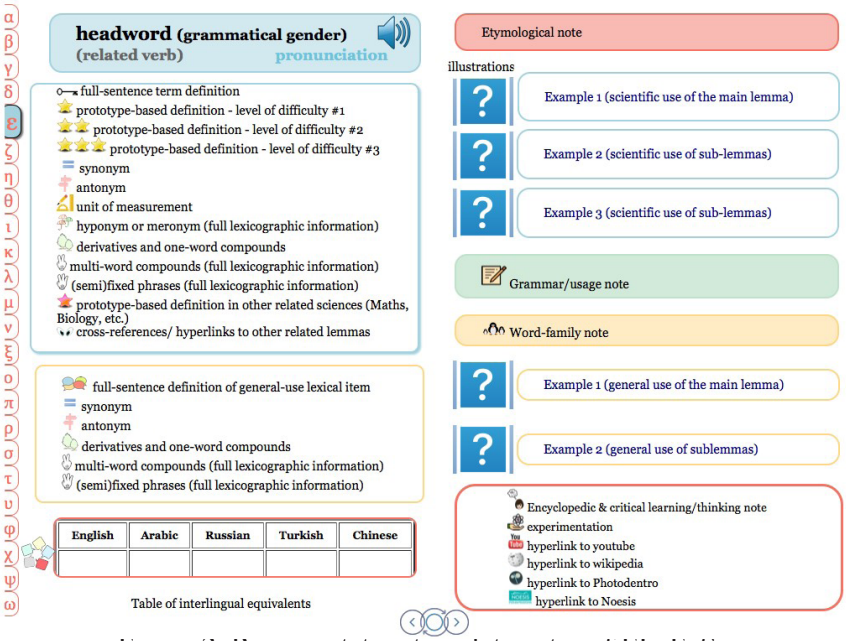

Figure 2. Representative template entry of ELeFyS.

(Semi)fixed phrases are in most cases collocations, such as *έπεσε η (ηλεκτρική)*[6] *ασφάλεια* "the (electric) fuse has blown" (terminology) or *γεμίζω τις μπαταρίες μου* "to recharge my batteries" (general use).

Multi-word compounds abide by the following lemmatization criteria: they are systematically entered as sub-lemmas under the main noun entry, which may constitute either the head or non-head of the compound, e.g. under the headword *μαγνήτης* "magnet" the multi-word compounds *φυσικοί* vs *τεχνητοί μαγνήτες* "natural vs artificial magnets", under the headword *επαφή* "contact" the multi-word compound *φακοί επαφής* "contact lenses" (general use).[7] Such a decision has been made on the grounds that learners will benefit from the contrastive or combinatorial behavior of scientific and general-use lexical items. For instance, under the main lemma *ρεύμα* "current" they can find lexicographic information for electric current, river current and current as "opinion" or "tendency", being thus exposed to the unifying and differentiating features that underlie the item's senses, constructions and uses in scientific and everyday language. For all of the aforementioned entry components a full range of lexicographic information is supplied. In contrast, morphologically related derivative adjectives, e.g. the adjective *μοριακός* "molecular" under the main lemma *μόριο* "molecule", are entered as run-ons, without any definition, but selectively used in examples (mostly those that are more frequent in school language corpora). Moreover, taking into account that word family information is meaningful as an indication of lexical richness and breadth (Laufer & Nation 1995), ELeFyS subsumes

6 It is very common for several scientific terms to be used both as multi-word compounds and as single-word nouns through the process of ellipsis, i.e. *ηλεκτρικό ρεύμα-ρεύμα* "electrical current"-"current". Actually, in some cases the elliptical noun head form is more frequent than the compound; that is why the non-head part of the compound (adjective) is put in parentheses.

7 Only one deviation can be found from this systematic approach, that is in cases where abstract nouns construct multi-word compounds that fall within different subfields of Physics. For instance, the word *ενέργεια* "energy" constitutes the head of several multi-word compounds that fall within the subfield of Properties Matter and Atomic Structure, i.e. *ατομική ενέργεια* "atomic energy", *πυρηνική ενέργεια* "nuclear energy" or the subfield of Heat & Temperature, i.e. *θερμική ενέργεια* "thermal energy". In order to abide by the thematic arrangement of the dictionary, such multi-word compounds are treated as main lemmas, entered at the appropriate section of ELeFyS.

general-use words of the same family into word family notes, e.g. the word family note under the lemma *κύκλωμα* "circuit" includes items such as *κύκλος* "circle", *κυκλώνω* "to circle", *κυκλικός* "circular", *ανακύκλωση* "recycling".

As such, not only is a thorough understanding of the scientific concept obtained, but the learners' consciousness on the productivity and polysemy of the Greek language is also raised.[8] Furthermore, since the chief macro-structural criterion must be user-friendliness, such a distribution facilitates the user's search: the noun, i.e. the most frequent grammatical category (Anastassiadis-Symeonidis 1986) is the systematic search unit. Lastly, equal weight is given to all dictionary-relevant components, such as grammar, style and register, pragmatic features, relationships of synonymy and antonymy, etymology, etc., to help learners replace the apparent linguistic randomness with systematicity, and thus learnability (see Section 3.2.4). The orthographic conventions suggested by the *Dictionary of Standard Modern Greek* (1998) were used in ELeFyS.

3.2 Microstructure

3.2.1 Definitions & Senses

Definitions are fine-grained particularly in the case of polysemous words. Word senses of scientific terms are promoted to appear at the top left side of the entry in a light blue frame, whereas their corresponding senses in general vocabulary follow in a yellow frame. Besides conventional defining formulae (such us prototype and genus/differentiae-based definitions), contextual defining formats are used, such as full-sentence definitions (Rundell 2006), embedded in a rich microstructure. The scientific definitions are of gradual difficulty following a ranking from the simplest (suggested for a primary observation/understanding of the phenomenon) to the most complex (leading to academic wording). For instance, the main lemma *(ηλεκτρική) επαφή* "(electric) contact" is firstly defined in a more pedagogical contextual format:[9]

(1) *Ο διακόπτης μοιάζει με κουμπί που μπορείς να το ανεβάζεις ή να το κατεβάζεις με το δάχτυλό σου. Σε βοηθά να ανοίγεις και να κλείνεις μια ηλεκτρική συσκευή ή να ανάβεις και να σβήνεις το φως στο δωμάτιό σου*. "A switch looks like a button which you can push up or down with your fingers. It helps you to turn on/off an electric device or the lights in your room."

Subsequently, more complex definitions are displayed in order to cover the different needs of learners in accordance with their age, cognitive state and linguistic competence, e.g. a definition of medium difficulty:

(2) *μηχανισμός που 'σταματά' ή 'ξεκινά' τη σύνδεση σε ένα ηλεκτρικό κύκλωμα* "A device that 'starts' or 'breaks' the connection in an electric circuit."

and a definition of great difficulty:

(3) *στοιχείο ενός ηλεκτρικού κυκλώματος, με το οποίο μπορούμε να διακόπτουμε τη ροή του ηλεκτρικού ρεύματος* "A component of an electric circuit that interrupts the flow of electric current."

Gradation of conventional definitions is flagged by one to three stars, so that difficulty in content or form can be marked. Of course, not every lemma exhibits the four suggested stages of gradual definitions; it depends on the conceptual difficulty or abstraction of the term, and the linguistic means

8 Although we are aware of the counter-argument that sub-lemmas and run-ons are not favoured in pedagogical dictionaries, we proceeded with such a distribution of lexicographic information into multi-lemmas, thus prioritizing the learners' needs to establish thematic and taxonomic conceptual relations (Mirman et al. 2017) in science and everyday life.

9 Full-sentence scientific definitions placed in a complete microstructure are flagged by a key symbol.

available for its wording.[10] The same gradual pattern is also followed for the full-sentence definitions of the corresponding general-use words, this time from the literal to the figurative meaning.

We consulted several resources in order to choose the definition wordings that best fit the needs of our targeted user group, such as other specialized or general dictionaries (i.e. *Oxford Science Dictionaries, Cambridge and MacMillan Dictionaries, Dictionary of Standard Modern Greek*, etc.), Wikipedia, and the school textbooks. It should be mentioned, though, that since ELeFyS is multi-functional it does not aspire to catalogue senses in exhaustive detail; therefore, we opted for those general-use meanings that are highly frequent in the school textbook corpus. For instance, we omitted the meaning "tumor" from the lemma *όγκος* "volume" and the meaning "to have intercourse with somebody" for the fixed expression *έρχομαι σε επαφή με κάποιον*.

In specific cases, glosses in parentheses are used for a more informal explanation of the definition's wording, in order to facilitate learners' understanding, e.g. in the lemma *άτομο* "το μικρότερο συστατικό (=κομμάτι) της ύλης" "the smallest component (=piece) of matter" or in order to provide clarifying remarks, e.g. "οι ασφάλειες είναι διακόπτες που σταματούν αυτόματα τη ροή του ηλεκτρικού ρεύματος σε περίπτωση βλάβης (π.χ. βραχυκύκλωμα)" "electric fuses are switches that automatically interrupt the flow of electric current in cases of device breakdown (e.g. short circuit)".

3.2.2 Examples

A broad spectrum of examples is offered in light blue (scientific terms) and yellow frames (general use) at the right side of the page, so that the lemma's syntactic, collocational and pragmatic behavior is fully illustrated. Both authentic and lexicographer-made examples (Laufer 1992) are used, in order to reveal the words' patterning and preferences; however, the pedagogical intent of ELeFyS is to provide meaningful examples, tailored to the communicative and academic needs of primary and secondary school children. Thus, in most cases we customized the authentic corpus-based examples by rewording or/and simplifying them.[11] The examples written for the main senses (scientific and general-use) of the polysemous Greek word *ασφάλεια*, "electric fuse" but also "safety/security", are portrayed below:

(4) *Μόλις ο ηλεκτρολόγος μπήκε στο διαμέρισμα, βρήκε τον πίνακα με τις (ηλεκτρικές) ασφάλειες πίσω από την πόρτα. Κάποια από αυτές ήταν καμένη. Την άλλαξε και άναψαν τα φώτα.* "When the electrician entered the apartment, he found the switchboard behind the door. One of the fuses had blown. He changed it, and the lights went on."

(5) *Η Ιβάνα δεν φοβάται τίποτα και νιώθει ασφάλεια στην αγκαλιά της μαμάς της.* "Ivana is not afraid of anything and she feels safe in her mother's arms"

Pedagogy is also reinforced by the 'continuous presence' of four children-protagonists, i.e. Timos, Zoe, Ivana and Aylan, throughout the dictionary pages.

3.2.3 Interlingual Equivalents

Given its design principles, content, and form ELeFyS can be also appropriate for L2 learning. Towards this end, a table of interlingual equivalents in five languages (English, Arabic, Russian, Turkish

10 To ensure intelligibility, a 'controlled defining vocabulary' was used in the low-difficulty definitions, consisting of high-frequency words which the learner is expected to know sufficiently well. However, due to the conceptual complexity of special terms, definitions of great difficulty may include more demanding vocabulary.

11 It should be noted that in specific cases of hyponyms, meronyms or morphologically-related sub-lemmas, illustrative examples substituted definitions, in order to avoid dense information and cognitive burden from the definition section.

and Chinese) contributes to the thorough understanding of terminology.[12] These five languages were selected on the grounds of their criticalness at this specific socio-political juncture for Greece. At the same time, it helps students make interlingual and intercultural associations. In translating the terms, we consulted bilingual (electronic and print dictionaries).[13]

3.2.4 Grammatical, Etymological & Usage Notes

ELeFyS routinely provides micro-structural information on the form and use of each lemma. Word-formational indications are given as run-ons (derivative and compound words not lemmatized separately) and word family notes (see section 3.1.3), thus enabling the use of the word-part analysis (Oxford 2016) or morphological segmentation strategy (Anastassiadis-Symeonidis & Mitsiaki 2010) during the learning process. Additionally, etymological notes make a vital contribution to the new vocabulary's reception and use (see also Chatzisavvas 2005), as students benefit from the discovery of the word's history. For instance, they realize the etymological connection of electricity to the Ancient Greek *ἤλεκτρον* "amber", and get informed of the early observation of Ancient Greeks that amber exhibits electric properties. However, they also find out that the scientific term was formed much later in French, being based, however, on the Ancient Greek *ἤλεκτρον*. Therefore, they become familiar with the word's origin and the different historical paths through which terminology arose, while at the same time they detect the similarities between the first and second language in the case of internationalisms, e.g. *electricity* (English), *elektrik* (Turkish) *электричество* (Russian). In verifying the lemma etymology, we consulted the *Dictionary of Standard Modern Greek* (Petrounias 1998) as well as the digital version of the *Dictionary of Ancient Greek* (from the Center for the Greek Language website).

Furthermore, explicit grammatical and pragmatic guidance is offered through grammar and usage notes, which include information on the lemmas' structural features (see Section 2), i.e. spelling, pronunciation, inflection, syntax, +learned register, etc. Likewise, some of the headword's inherent grammatical properties are included, such as the grammatical gender (denoted by the definite article), the absence of plural form, lack of inflection for loanwords, related verbs, and so on. Finally, it should be noted that ELeFyS has dispensed with phonetic transcriptions, since learners are able to hear what a lexical unit sounds like.

3.2.5 Encyclopedic & Critical Learning/Thinking Notes

For every single article thought-provoking material is provided in the following forms:

- notes raising issues or questions that expand encyclopedic knowledge, e.g. the note included in the lemma *ηλεκτρισμός* "electricity" makes reference to the early observation made by Thales of Miletus who discovered that if he rubbed amber (*ἤλεκτρον*) with a piece of fur it could attract lightweight objects
- suggestions for experimentation that enhance critical thinking or/and intercultural sensitivity, e.g. the note included in the lemma *έλξη* "attraction" suggests the following experiment: "Rub a plastic pen on a wool sweater. Then put it near paper cut in small pieces. What do you observe?" or the note under the lemma *(καλός) αγωγός (θερμότητας)* "thermal conductor" makes reference to igloos, the double-walled ice shelters made by Eskimos, in order to prevent heat conduction
- hyperlinks to Wikipedia for a deeper understanding of physical phenomena and their history
- hyperlinks to videos in YouTube

12 Since the primary objective of such a specialized dictionary is to facilitate academic vocabulary/language learning, only the term interlingual equivalents were given.

13 At the moment, the translated terms are also checked by native speakers of the five aforementioned languages.

- hyperlinks to Digital Educational Resources from Photodentro – The Greek National Aggregator of Educational Content), and
- hyperlinks to multimedia available at Noesis (Thessaloniki Science Center & Technology Museum).

3.2.6 Pictorial Illustrations

Pictorial illustrations aid reception and production, thus complementing verbal explanations, leaving little room for misinterpretations, and promoting retention. The illustrations we have employed were selected from repositories that allow re-use and attribution under standardized licenses (Creative Commons). To serve the pedagogical role of ELeFyS, the illustrations were selected on the basis of their target-group age and cultural background (Ilson 1987; Biesaga 2016).

4 Conclusion

ELeFyS is an innovative, specialized Greek Science Dictionary intended for school use and an open educational resource that promotes learner autonomy through inquiry-based, strategy-based and cross-disciplinary learning. As a joint effort and a product of interdisciplinary collaboration between experts in the areas of applied linguistics and science education, it aims at bridging the gap of the parallel teaching/learning of science and language, greatly supporting the development of (meta) cognitive learning strategies. The dictionary micro- and macro- structure, the digital modality and the linguistic, conceptual or cultural stimuli provided render ELeFyS a valuable resource in the context of interactive learning in a school setting.

The compilation of a digital dictionary is a dynamic process, which means that it should be constantly revised and updated with new lemmas; therefore, our team welcomes feedback from academics, teachers and students. To this end, some small-scale pilot studies have already been conducted and partially reported (Mitsiaki & Lefkos 2017), providing positive feedback about the usability of ELeFyS. Additionally, a large-scale implementation is scheduled as the next step. Finally, in order to facilitate teachers and students in using such a dictionary creatively, ELeFyS will be complemented by a student's workbook, which is under development at the moment.

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