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Bilingual Science Lexicon of Pre-Serviced Primary School Teachers

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Abstract: Bilingual teaching has experienced rapid growth in the Spanish educational panorama and numerous university programmes have emerged with the aim of training future CLIL (Content and Language Integrated Learning) teachers. However, there is little research assessing the level of linguistic competence in Spanish and foreign languages of future teachers, especially those who are studying for a bilingual degree. Although this work is part of a broader project that analyses bilingual lexical competence in subjects related to the Social Sciences and Experimental Sciences, we focus on the analysis of lexical availability of content related to the teaching of science. The sample consisted of 46 students of the Degree in Primary Education at the University of Extremadura. Using a lexical availability test, lexical production in Spanish and English is analysed and compared to determine whether the fact of studying in English affects the acquisition and consolidation of lexical knowledge in Spanish. The results show that there are no significant differences in lexical production between Spanish and English. In addition to the quantitative data, results from the qualitative analysis are presented, analysing the most available words and the organisation of the lexicon in both languages.

Keywords: initial training; bilingual education; vocabulary; lexical availability; science

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1. Introduction

Bilingual education has experienced rapid growth in the last two decades in the Spanish educational panorama, as a response to the challenge constituted by the development of multilingualism, which has become an objective of European and national language policies. As the Council of the European Union Recommendation 2019/C 189/03 [1] points out, we must not forget that increasing and improving language learning facilitates mobility in education, training, and work consolidates the European dimension of education and training, fosters the development of a European identity in all its diversity, and contributes to the development of citizenship and democratic competences.

Content and Language Integrated Learning, hereinafter CLIL, which emerged in the 1990s, represents a dual educational approach in which a language other than the mother tongue is used, in addition to the mother tongue, for learning and teaching content and language [2]. This approach, which underpins bilingual education in Spain, has spread widely throughout the country, with models varying from one region to another and being implemented at all levels of education, from pre-primary to secondary education. In parallel, in the context of higher education, the type of instruction called English as a Medium of Instruction (EMI) and defined as "the use of the English language to teach academic subjects in countries or jurisdictions where the first language (L1) of the majority of the population is not English" [3] (p. 2), has emerged. While the CLIL approach emphasises content and language learning with an interdisciplinary curriculum design,

EMI focuses on the contents to carry out a transdisciplinary approach to learner-centred teaching [4].

Research on CLIL and EMI has grown at the same time as its extension in schools. One of the areas that has attracted a significant amount of research, being both a challenge and one of the difficulties in the process of effective implementation, has been that of teacher education. These studies have tried to lay the foundations of the necessary competences that a teacher should have [5,6], to determine whether there are teachers adequately trained to teach their subjects in English [7,8], to make a diagnosis of the current situation [8–10] or to reflect on pedagogical issues associated with teaching through English [10–12]. In addition to the lack of well-designed teaching training, other challenges include the quantity of English provision and the students' English proficiency [13].

As far as the validity of the approach is concerned, research has mainly focused on assessing the linguistic benefits obtained by students enrolled in bilingual programmes, both at compulsory and higher education levels [14–20].

In the last decade, critical voices have emerged against bilingual educational programmes, questioning the characterisation, implementation, and research of and in CLIL [21] and offering a critical perspective on the use of English as a medium of instruction at universities [22]. Some pieces of criticism of these programmes include, among others, those affecting the learning of content at the disciplinary level and of the students' own mother tongue. Thus, on the one hand, studies carried out in the Spanish context, both at primary and secondary levels, suggest that learning would be impaired, calling into question the suitability of this approach for the acquisition of content in non-language areas taught in a foreign language [23–25]. However, there is also evidence showing contrary results, in which the effects are favourable to CLIL students who outperform their peers who receive instruction of Natural Science subjects in the mother tongue, especially in the long term [26,27], or neutral, in the sense that CLIL or EMI instruction had no negative effects on content learning [28,29]. As Lasagabaster [30] concludes, after a review of studies, "EMI should not hamper content learning if programmes are cogently designed and implemented" (p. 41).

On the other hand, there is criticism of the level of competence in the first language (L1) achieved by pupils in bilingual programmes, where again, there are contradictory results, although recent studies have shown that bilingual teaching does not have a detrimental effect on L1 development and performance. Thus, the results of Merisuo-Storm and Soininen's study [31] show that pupils in CLIL classes had achieved significantly better spelling and reading skills in the first language than pupils in non-CLIL classes. Moreover, their attitudes towards reading and writing were more positive than those of their peers in mainstream classes. Similar results were reached by Pérez Cañado [21], in whose study bilingual pupils outperform their non-bilingual counterparts in the L1 subject at the end of primary and secondary education. For her part, Barrios [32] concludes in his work, after a rigorous selection of homogeneous and therefore, comparable samples, that the curricular competence in Spanish (CLIL) of CLIL pupils was not negatively affected when school grades in L1 were compared with those of their peers in regular classes. We are not aware of the existence of studies that address this issue in the EMI context, especially regarding the development of specialized and/or scientific lexicon, specific to the disciplines of university training programs.

This brief review shows how the effects of CLIL on L1 or content learning need to be investigated more extensively, not only because of the discrepant findings obtained, but also because, unlike the benefits of the CLIL approach on foreign language learning, research on its consequences on the acquisition of academic content received through the foreign language and on L1 proficiency levels is scarcer. This is also a conclusion that can be extrapolated to research in higher education where more empirical research in essential to determine its effect, discover the existing difficulties, provide solutions for language learning and content comprehension [13], and analyse if EMI hampers students' content-knowledge learning.

In this paper, we combine two of the aforementioned issues: teacher training in bilingual programmes and the acquisition of content in EMI programmes. More specifically, we focus on the lexical analysis of the lexis of trainee primary school teachers, both in L1 and in the language of instruction (English), in relation to the scientific content of the subjects studied in a foreign language. As Santos Díaz [33] points out, there is little research that assesses the level of linguistic competence in Spanish and foreign languages of future teachers, especially those who are studying for a bilingual degree. To develop the analysis, we use the studies of available lexicon as a basis for this work.

Lexical availability, understood as the tool or technique that allows us to obtain the available lexicon [34], was developed within the framework of the work for the elaboration of the *Français Fondammental* [35], when the criterion of frequency was joined to that of available vocabulary [36], thus allowing the establishment of a basic vocabulary aimed at facilitating the acquisition of French by foreigners. The following decades have seen numerous advances in conceptual and methodological developments [37] and applications of availability, as the results, according to López-Morales [38], have allowed us to describe the lexical norm available in different areas and make inter-dialectal comparisons, determine the lexical characterisation of different groups and geographical areas, help to improve knowledge of the mental lexicon or plan language teaching. The latter is one of the most developed applications, as it is also the pioneer [39], and numerous studies have been carried out with different objectives [40]: detection of spelling errors in order to propose didactic solutions, analysis of specialised vocabulary or lexical selection, among others. Another very fruitful area is the analysis of transfers between two languages, in the field of language contact, to which we should add a more recent one that analyses the development and manifestation of cognition [39]. This shows us how valid lexical availability studies are still valid today, since not only are the initial aims maintained, but also, the methodological approaches have evolved, especially with the development of new formulas and calculations which, as Herranz Llácer and Marcos Calvo [41] point out, help us to understand the depth and projection of lexical availability studies today.

Among the work carried out recently, a significant number of studies focus on the analysis of non-native language learners. One group of studies stands out among them, which refers to future teachers and their training, analysing in a generic way their available lexicon, both in L1 and L2, and how the received training influences the constitution of a specialised lexicon, the relationship between reading habits and lexical proficiency or predictors of lexical competence [42–48].

Likewise, another line of studies proposes an approach to the analysis of semantic categories through graphs [49], showing the usefulness of these structures, based on the mathematical Graph Theory, to graphically represent the relationship between the words of a group based on their position and the relationships between them. In the resulting graphs, the nodes are available words and the edges that join them represent the semantic relationships between them, expressing the length of these, quantified as a weight, the strength of the relationship between nodes. Thus, graphs allow us to go deeper into the analysis of the organisation of the mental lexicon, examining the lexicon available in the mother tongue [50,51] or checking whether there are differences between native speakers and learners of non-native languages [52,53] or between the different languages—mother and foreign—of the informants [42].

The Degree in Primary Education at the University of Extremadura is offered in two modalities: bilingual and non-bilingual. In the former, students take 50% of the subjects in English, while in the latter, all subjects, except for those related to the specialisation in foreign languages, are taught in Spanish. In this context, the research we are carrying out, within the framework of an R + D + I project entitled "Development of plurilingualism in Extremadura: analysis of affective, linguistic and disciplinary aspects" (IB20074), has two objectives. Firstly, we aim to examine the incidence of the instructional model on the productive vocabulary in Spanish on topics related to the subject of Didactics of Matter and Energy, a compulsory subject of the degree. Secondly, we aim to compare the lexis available

in Spanish and English in the case of students who follow the bilingual programme and who take the subject in English. To achieve these objectives, the questions that guide our study are:

(1) Do students in bilingual programmes have less productive vocabulary in Spanish in the lesson 'Matter and Energy' than their peers taking the subject in Spanish?
(2) Are there differences in the Spanish and English lexicon of the bilingual group?

2. Materials and Methods

This piece of research was carried out at the University of Extremadura, during the 2021–2022 academic year and follows the methodological guidelines of the *Proyecto panhispánico de disponibilidad léxica* (Panhispanic Lexical Availability Project). Within the framework of this project, some common guidelines for action were decided: the size and selection of the sample—400 pre-university students, open lists with a time limit of two minutes to collect the lexicon of each category, typology of assessable prompts (the same as those of the first French studies)—analysis variables and homogeneous editing criteria. However, from this project, new studies have been developed considering different informants, such as, in our case, specific editing guidelines and new variables in the case of non-native language informants or the extension of the prompts surveyed.

The research design used is cross-sectional, descriptive, and non-correlational. The sampling carried out was not probabilistic, as the students were chosen intentionally, by convenience.

2.1. Participants

The final sample of the present research was composed of 46 students (n = 46) from the Faculty of Education and Psychology (Badajoz, Spain) and the Faculty of Teacher Training (Cáceres, Spain) at the University of Extremadura (Spain). The participants were in the second year of the degree in Primary Education and distributed as follows: 23 (50%) students in the bilingual programme and 23 (50%) in the regular degree (50%). All of them were taking the final part of the subject "Didactics of Matter and Energy", which future teachers at this stage take as part of their training for the subsequent teaching of the subject Knowledge of the Natural, Social and Cultural Environment at the Primary School stage. Although this subject is taught by different teachers, it has a common teaching sheet, and therefore, the competences, contents, and timetable are identical.

As regards gender, the sample is distributed in the following way: 30 women (65.2%) and 16 men (34.8%). The average age of the participants is 19.89 years old.

2.2. Research Instrument

The data collection was carried out using a questionnaire in which students answered questions of sociological and academic interest, such as gender, age, background in language learning and in bilingual programmes, and academic studies prior to their incorporation to the degree. In addition, the students took a lexical availability test, in accordance with the approaches set out at the beginning of Section 2. The choice of this research instrument is supported by its use in similar research that has delved into the lexical analysis of future teachers [43,45,46,54] and by its suitability for achieving the objectives of this research.

The informants, using the open list system, were asked to write down, for a timed two-minute period, all those words in Spanish and English (bilingual group) and only in Spanish (regular group) which they knew related to a given category, of which they were informed at the precise time of taking the test.

Three prompts were surveyed: "Energy", "Solar System", and "Matter Transformation". The choice of the subject areas was determined not only by the content of the subject they received during their training, but also by the content they would later have to teach as future teachers.

2.3. Procedure

Participants completed the questionnaire in English and/or Spanish at the end of the second semester of the 2021/2022 academic year, in a single session, being informed of the objectives of the research and of the voluntary and anonymous nature of their participation.

After filling their consent form, they filled in the sociological questionnaire and then completed the lexical availability task, in which they wrote down all those words in Spanish first, and then in English in the case of the bilingual group, that they knew related to the prompts surveyed. As we have stated before, they were informed about these categories at the precise time of the test and they were presented one after the other, so that they could not go on to complete data from the next category until the two minutes had elapsed.

Once the questionnaires were completed, the data were processed. The study variables were coded and statistically processed with the IBM SPSS v.23 statistical package. For the edition of the lexicon available in Spanish, the guidelines established by Samper Padilla [55] and Samper, Bellón, and Hernández [56] were followed, and for the lexicon available in English, those established by De la Maya Retamar and López Pérez [43] and Santos Díaz [33]. Thus, spelling errors have been corrected, repeated words, unintelligible words, and words written in languages other than those of the tests have been eliminated, inflected forms have been neutralised, and words have been unified in terms of spelling. All the words evoked by informants in each prompt were admitted, for better understanding of the relationships between words, in accordance with the criteria retained by Trigo and Santos [42]. The treatment of the data from the lexical availability test was carried out with the Dispogen II package [57] and Dispógrafo [49] for the generation of associative graphs.

3. Results

3.1. Data Related to Spanish Lexicon

The students evoked a total of 1556 words, with an average of 33.82 words per informant, distributed among the categories surveyed, as shown in Table 1.

Table 1. Total words and terms according to topics.

Table	*n*	Total Words	Average Words	Total Terms	Cohesion Index
Energy	46	413	8.97	139	0.064
Solar system	46	639	13.89	121	0.114
Matter transformation	46	504	10.96	95	0.115

The prompt with the highest number of words was Solar system, with an average of 13.89 words per informant, followed by Matter transformation, with 10.96 words per informant and, finally, Energy, with 8.97 words on average. If we take into consideration the number of terms, that is to say, the number of different words evoked, we observe that the category with the lowest production, Energy, contains the most different words (139), followed by Solar system with 121 and Matter transformation with 95.

The cohesion index, calculated according to the formula proposed by Echevarría [58] and obtained by dividing the average number of responses obtained by the number of terms, shows that the most compact category is Matter transformation, with a value practically identical to that of Solar system. This indicates that the responses of the students in both prompts are more coincident than those provided in the Energy category, where the cohesion index is reduced by half.

If we take into consideration the instructional model followed, Table 2 shows the data on the vocabulary produced by the informants in the bilingual degree and those in the regular classes.

Table 2. Total words and terms according to topics and instruction model.

Topic	Total Words		Average Words		Total Terms		Cohesion Index	
	BD [1]	RC [2]	BD	RC	BD	RC	BD	RC
Energy	202	211	8.78	9.17	96	86	0.09	0.10
Solar system	324	315	14.09	13.69	92	81	0.15	0.16
Matter transformation	270	234	11.74	10.17	72	61	0.16	0.16

[1] Students from bilingual degree. [2] Students from regular classes.

Except for the Energy prompt, where the average number of Spanish responses per respondent is higher in the regular classes group, 9.17 compared to 8.78 in the bilingual degree group, the data are more favourable to the group who have taken their classes in English, as they produce more words in Spanish, with higher averages per respondent. In the case of the terms, the superiority is even greater as they produce a higher number of different words in the three categories surveyed.

In order to check whether these differences are statistically significant, we proceeded to perform mean comparison tests. After checking the assumptions to be met by the data series, we applied parametric tests in the case of the Energy category and non-parametric tests in the rest, as the data from the non-bilingual group did not meet the assumption of normality in the Matter transformation category, and the homogeneity of variance was not met in the Solar system prompt either. The results obtained indicate that there are no significant differences in the total vocabulary evoked (t = 0.526, $p = 0.601$), nor in the vocabulary produced in any of the three categories (Energy: $t = -0.333$, $p = 0.740$; Solar system: $Z = -0.353$, $p = 0.724$: Matter transformation: $Z = -1.072$, $p = 0.284$).

From a qualitative point of view, it is possible to analyse the most available words in both groups to determine whether there are differences beyond the number of words produced. Table 3 presents the 10 words the lexical availability index (LAI) of which, expressed as a percentage, is the highest in each of the categories.

In the Solar system category, we find that the students agree on 7 out of the 10 most available words, and the first four are practically in the same positions. It is curious that both groups specify "planet" as the most available word when the "Sun", evoked in second place, is the central element of the solar system. However, despite these coincidences, we estimate that, on the whole, considering the words not shared, the lexicon of the students in the bilingual programme is more specialised, while that of the regular class is more generic in nature. For the Matter transformation prompt, however, the opposite is true. It is the regular group that refers to more specific processes, such as "boiling", "evaporation", "melting", etc., whereas in the bilingual group, the references are more generic. The Energy category is the one with the fewest shared words, 5 out of 10. In this prompt, there is a conceptual category which is very present, that of sources or forms of energy, with 6 of the most available words in the bilingual group and 7 in the non-bilingual group. It is worth highlighting the appearance of two terms among the most available words for this prompt. On the one hand, "heat", in the bilingual group, because, although this term refers to the transfer of thermal energy between two bodies at different temperatures, it is a concept that is often confused with a form of energy. However, we cannot determine in what sense it has been evoked. On the other hand, and in the case of the non-bilingual group, the term "electricity" appears in the tenth place, which is often incorrectly associated with a type of energy.

Table 3. Most available words in the different categories according to instruction model.

		Bilingual Degree			Regular Classes	
		Word [1]	%LAI		Word [1]	%LAI
SOLAR SYSTEM	1	planet	65.26	1	planet	69.22
	2	Sun	61.16	2	Sun	50.76
	3	Earth	46.47	3	star	39.97
	4	star	38.48	4	Earth	36.04
	5	Moon	33.84	5	satellite	35.53
	6	orbit	28.73	6	Luna	33.79
	7	Mars	23.46	7	comet	27.79
	8	satellite	23.45	8	asteroid	25.30
	9	Milky Way	20.61	9	orbit	22.25
	10	Saturn	18.85	10	galaxy	19.82
ENERGY	1	kinetic energy	22.81	1	solar energy	46.37
	2	solar energy	19.80	2	kinetic energy	40.35
	3	heat	19.01	3	wind energy	27.99
	4	nuclear energy	18.47	4	nuclear energy	22.11
	5	temperature	17.31	5	electric energy	21.16
	6	chemical energy	16.86	6	hydraulic energy	20.54
	7	wind energy	15.61	7	thermal energy	20.10
	8	atom	14.96	8	renewable energy	18.18
	9	Sun	13.54	9	Energy transformation	17.69
	10	heat energy	13.51	10	electricity	16.17
MATTER TRANSFOR.	1	solid	43.60	1	solid	52.45
	2	liquid	43.41	2	liquid	52.00
	3	nuclear reaction	42.50	3	gaseous	48.69
	4	gaseous	41.09	4	fusion	30.01
	5	physical transformation	38.73	5	evaporation	26.70
	6	chemical transformation	27.65	6	physical transformation	25.04
	7	chemical reaction	22.75	7	sublimation	23.67
	8	energy	21.82	8	solidification	21.41
	9	aggregation state	19.92	9	chemical transformation	20.04
	10	state transformation	18.40	10	boiling	17.25

[1] Originally in Spanish. Words not shared by the two groups are marked in grey.

3.2. English Lexical Data

In this section, we focus specifically on the sub-sample composed only by students following the bilingual degree in order to compare the lexis produced in Spanish and English. Table 4 shows the total number of words and terms, the averages per respondent and the cohesion index in the three categories analysed.

Table 4. Lexical data in English and Spanish by the students from the bilingual program.

Topic	Total Words		Average Words		Total Terms		Cohesion Index	
	S [1]	E	S	E	S	E	S	E
Energy	202	170	878	7.39	96	74	0.09	0.10
Solar system	324	286	14.09	12.43	92	92	0.15	0.14
Matter transformation	270	266	11.74	11.57	72	72	0.16	0.16

[1] E: English; S: Spanish.

The students in the bilingual programme evoked a total of 796 words in Spanish, which represents an average of 34.60 words per informant, while in English the result is somewhat lower: 722 words and 31.39 words on average. Figure 1 shows the averages

for the three prompts, with slight differences in favour of Spanish, except in the Matter transformation category, where the averages are practically identical.

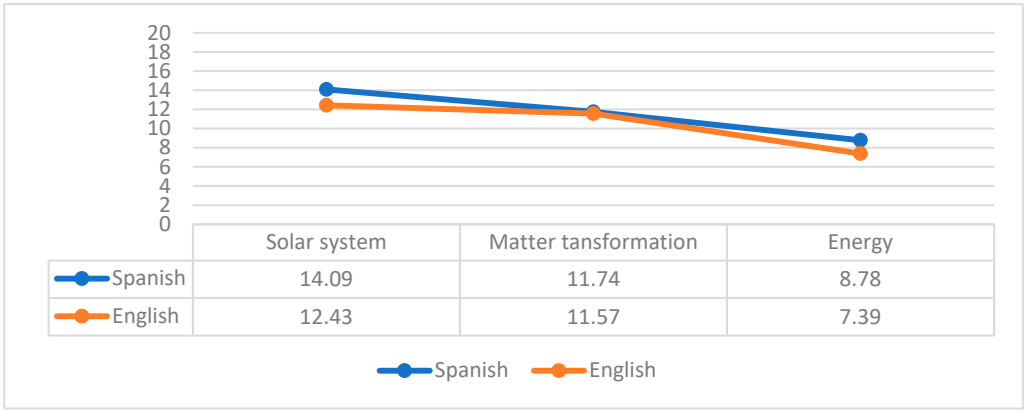

Figure 1. Word averages in the three categories.

In the case of terms, the number of different words is the same in the Solar system and Matter transformation prompts, with differences being found only in the Energy category, where students produce 23% more terms in Spanish than in English. Finally, as far as the cohesion index is concerned, the values achieved are practically identical in both languages.

In order to determine whether these quantitative differences are statistically relevant, we have carried out means comparisons through paired t-tests and Wilcoxon Signed-rank tests, the latter only for the Energy prompt, as the English data do not meet the assumption of normality. The results indicate not only that there are no differences in total lexical production between the two languages (t = 2.399, p = 0.25), but also that there are no differences in the categories, considered individually (Solar system: t = 1.903, p = 0.70; Matter transformation: t = 0.378, p = 0.709; Energy: $Z = -1.703$, p = 0.89).

Qualitatively, we return to the 10 words with the highest lexical availability index (LAI) in the two languages in each of the categories (Table 5).

Table 5. Most available words in the different categories according to language.

		Spanish			English	
		Word [1]	**%LAI**		**Word**	**%LAI**
SOLAR SYSTEM	1	planet	65.26	1	Sun	37.86%
	2	Sun	61.16	2	planet	36.08%
	3	Earth	46.47	3	Earth	28.93%
	4	star	38.48	4	star	22.85%
	5	Moon	33.84	5	Moon	18.96%
	6	orbit	28.73	6	orbit	16.23%
	7	Mars	23.46	7	satellite	11.60%
	8	satellite	23.45	8	gravity	10.94%
	9	Milky Way	20.61	9	galaxy	9.87%
	10	Saturn	18.85	10	Milky Way	9.62%
ENERGY	1	kinetic energy	22.81	1	nuclear energy	11.77%
	2	solar energy	19.80	2	Sun	11.37%
	3	heat	19.01	3	energy transformation	10.77%
	4	nuclear energy	18.47	4	light	10.56%
	5	temperature	17.31	5	kinetic energy	9.87%

Table 5. *Cont.*

		Spanish			English	
		Word [1]	**%LAI**		**Word**	**%LAI**
	6	chemical energy	16.86	6	heat	9.50%
	7	wind energy	15.61	7	pressure	9.44%
	8	atom	14.96	8	temperature	7.70%
	9	Sun	13.54	9	electric energy	7.15%
	10	calorific energy	13.51	10	potential energy	6.51%
	1	solid	43.60	1	physical transformation	30.29%
	2	liquid	43.41	2	nuclear transformation	28.96%
	3	nuclear reaction	42.50	3	chemical transformation	24.40%
	4	gaseous	41.09	4	solid	20.81%
MATTER	5	physical transformation	38.73	5	liquid	19.56%
TRANSFOR.	6	chemical transformation	27.65	6	energy	16.97%
	7	chemical reaction	22.75	7	gas	15.23%
	8	energy	21.82	8	aggregation state	15.11%
	9	aggregation state	19.92	9	fusion reaction	8.23%
	10	state transformation	18.40	10	fission reaction	7.94%

[1] Originally in English. Words not shared by the two groups are marked in grey.

When we analyse in detail the lexicon most available to the bilingual group in the two languages, Spanish and English, the first thing that stands out is the coincidence in the words evoked, especially in the categories of Matter transformation and Energy, where the words not shared are only two in each of them. In the latter prompt, this coincidence applies not only to the words, but also to the order of availability, which is the same for the first six words. Again, we find, for this prompt, words that refer to concepts whose relation to the concept of energy is at least questionable and which may be highlighting the existence of alternative ideas about this concept. These would include "heat", in Spanish and English, "atom" in Spanish, and "light" and "pressure" in English.

3.3. Comparisons between the Lexicon Using Graphs

From the lexicon evoked in the three categories, graphs have been generated with the Dispógrafo programme. This software allows us to analyse the semantic relations in the available lexicon by means of graphs, in which the words are represented by nodes and the relations between them by lines, with the arrow indicating the direction of the relations. For their generation, the programme establishes relations based on the frequency with which a certain word is mentioned in the lexical availability test and the frequency with which two words are mentioned in sequence. Thus, the graphs are interpreted "as semantic networks displaying the latent semantic ties underlying data" [49] (p. 82).

Due to lack of space, we will focus exclusively on the Solar system prompt. Table 6 shows the general data on the number of total nodes and edges and those with weights greater than or equal to 2 in Spanish (regular and bilingual groups) and in English (bilingual group).

Table 6. Nodes and edges. Prompt Solar system.

	Spanish (Regular Class)		**Spanish (Bilingual Class)**		**English (Bilingual Class)**	
	Total	**With Edges $\geq$ 2**	**Total**	**With Edges $\geq$ 2**	**Total**	**With Edges $\geq$ 2**
Nodes	81	81	92	92	92	92
Edges	228	24	227	22	212	18

The concept network of this prompt is made up, in the case of Spanish, of 81 nodes in the regular class, and 92 in the bilingual class. The number of nodes, i.e., the number of different lexical units, is higher in the latter group, although the number of edges or relations between them is slightly higher in the former. Comparing the network of concepts in Spanish and English of the bilingual class students, we observe that the number of nodes is identical in both languages, but the relationships are greater in the case of Spanish, both in the overall data and in those with weights greater than or equal (≥) to 2. In addition, we present the graphs generated with the Spanish terms, produced by the regular class (Figure 2), the bilingual class (Figure 3), and in English, also by the latter group (Figure 4). Since it is not easy to obtain information on the most available words from the complete graphs, we have eliminated the weakest connexions, pruning the graph of the edges with weight 1 (see data in Table 6) and eliminating the orphan nodes, i.e., those with no edges.

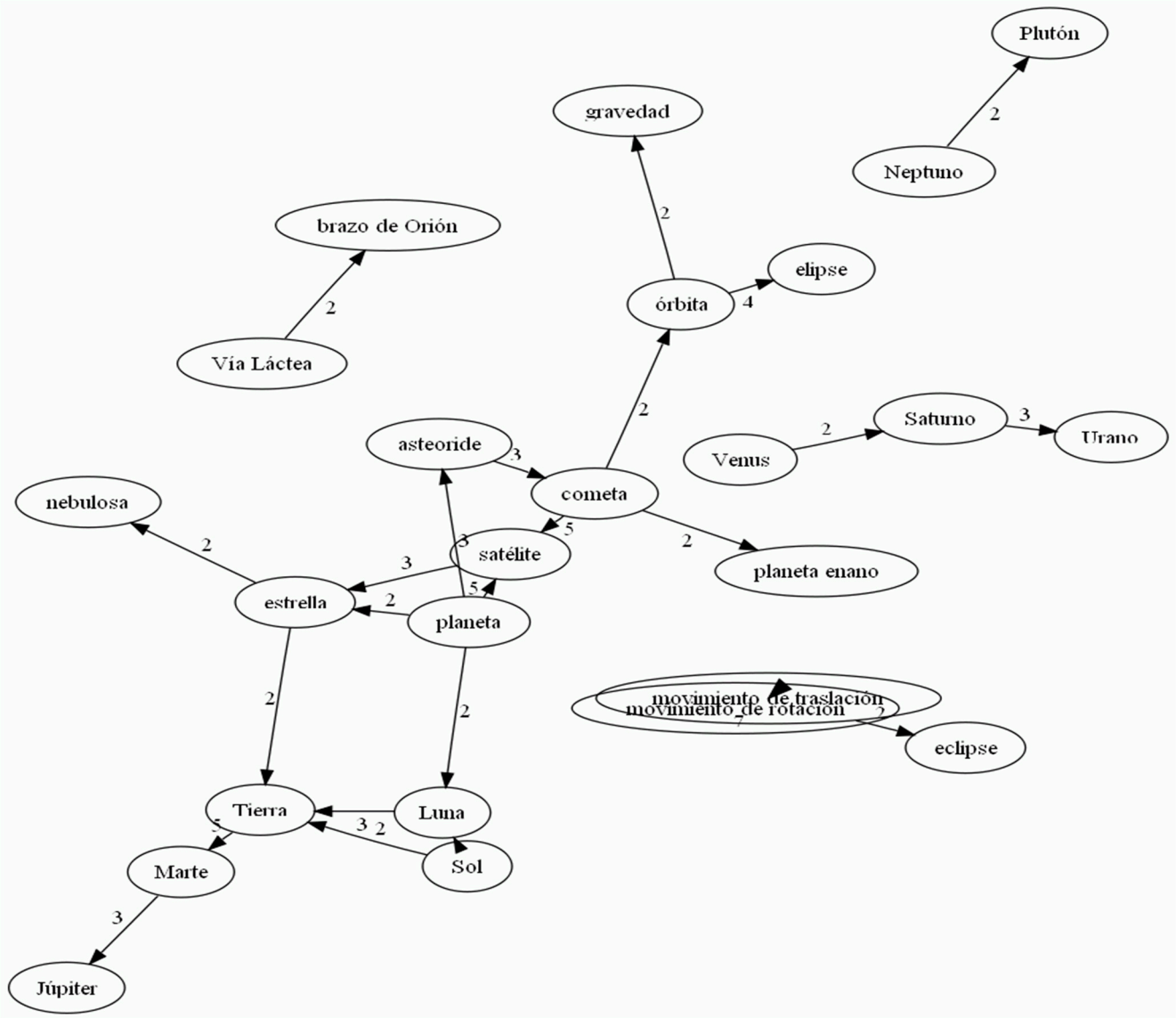

Figure 2. Solar system graph in Spanish (Regular class).

Regarding the graphs that represent the lexicon in Spanish, in addition to offering a clearer view of the most relevant relationships between the words evoked, we can also observe the categories and subcategories that make up the categories analysed. Thus, in Figure 2, we can see how two categories stand out among the students in the regular class: that of the planets, at the bottom right, and those of the categories of bodies in

the solar system, in the prompt, with the words "star" and "planet" being the linking words between the two categories. It is also in these two categories that virtually all the nodes are interrelated, with 2 neighbours. However, although the first category mentioned above groups 5 words, we also find other sub-groups with a lexicon related to the planets: "Neptune–Pluto" at the top and "Venus–Saturn–Uranus" on the right, in which the first word of the series is the evocative term for the rest and where the interrelationships are weaker as each node is associated with only one neighbour. We also find other subgroups unrelated to the previous ones between "Milky Way" and "Orion's arm", on the one hand, and "translational motion", "rotational motion", and "eclipse", on the other. In the latter subgroup, the first term evokes the most relationships, 7 in total, followed by the words "Earth", "planet", and "comet" with 5 each.

In the graph generated for the bilingual degree students (Figure 3), we see that the two categories mentioned for the regular class students—plants at the top and solar system bodies at the bottom—are present. However, there are some differences. Whereas in the case of planets, the words evoked by the regular class were found in three subgroups, in this class, all planets are found in a single group, with the words "planet" and "Earth" being the evocative terms and all nodes, except for "Neptune" and "Saturn", being interrelated with at least two adjacent words. Something similar occurs with the category of celestial bodies, although in this case the interrelationships are weaker. Likewise, only one subgroup appears unrelated to the previous ones, the one formed by "solstice-stations", so that in this group, unlike the previous one, the configuration of the graph appears sharper and better organised.

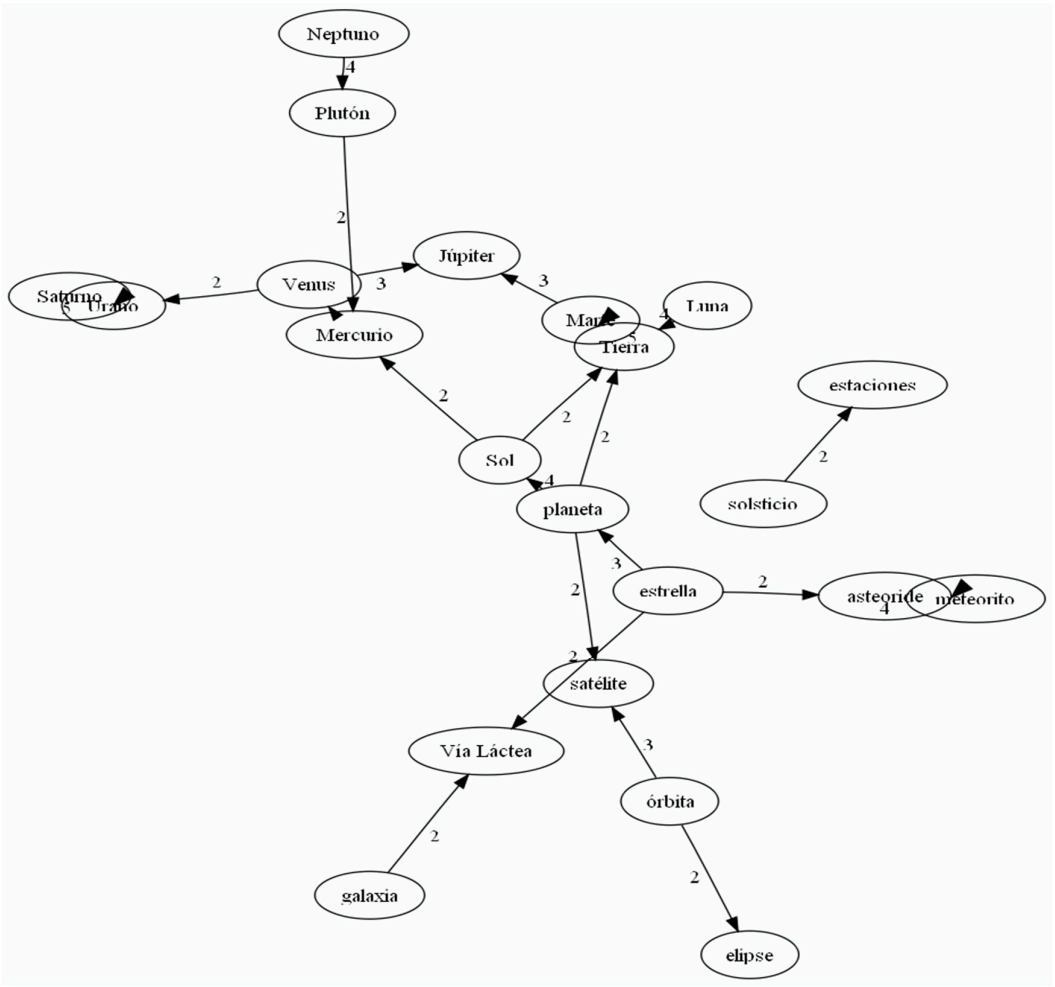

Figure 3. Solar system graph in Spanish (Bilingual class).

About the graph generated from the vocabulary that the bilingual degree students produce in English (Figure 4), a less structured configuration is observed than that revealed in Figure 3, in which the lexis evoked in Spanish by the same group was collected, as the categories are not so well defined. For example, "planets" are evoked, but also words of a different conceptual nature are evoked in the most interrelated words, and even relationships which are difficult to explain, such as that of "Galaxy" with "orbit" and this, in turn, with "rotation movement". The number of words produced is also lower than in Figure 3.

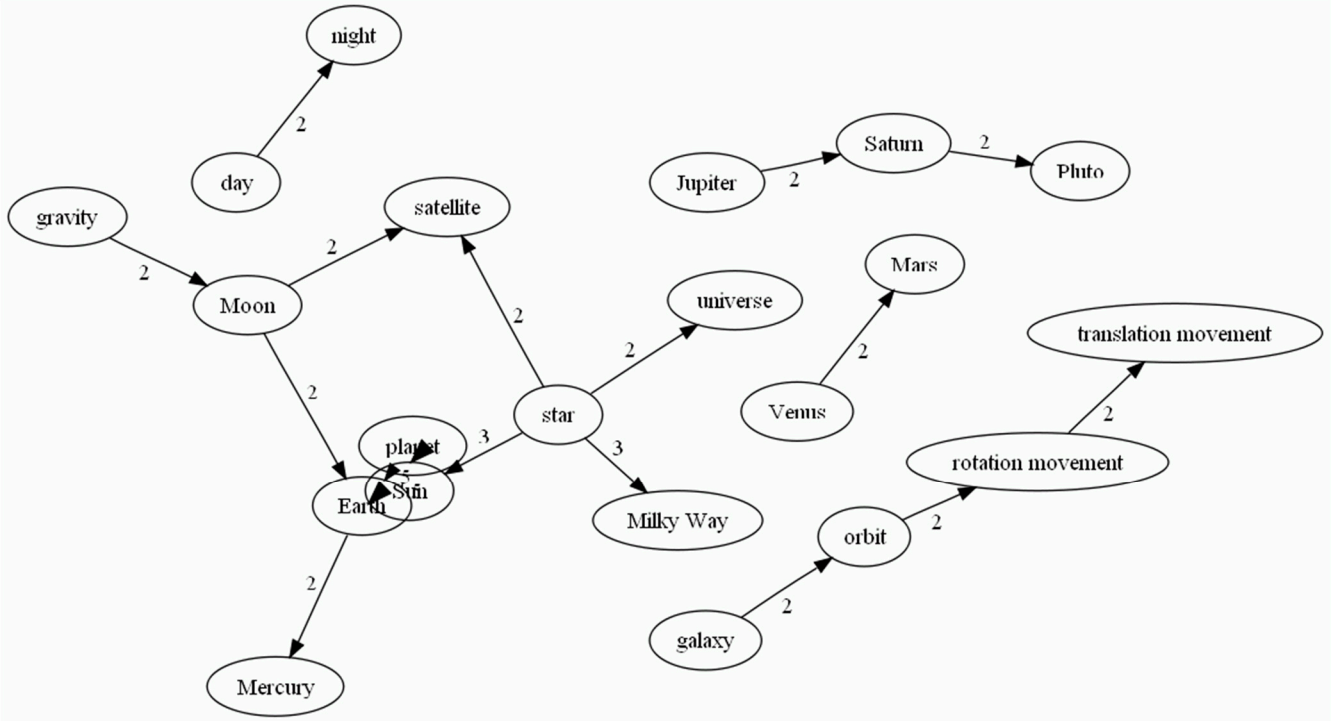

Figure 4. Solar system graph in English (Bilingual class).

4. Discussion

In this section, we return to the two research questions formulated at the beginning in order to discuss the results and interpret them from the perspective of previous studies.

The first question asked whether students from bilingual programmes have a less productive vocabulary in Spanish on the Matter and Energy subject than their peers taking the subject in Spanish. The results obtained show that, although the bilingual degree group evokes a greater number of words in two of the three prompts surveyed, there are no significant differences between the bilingual and non-bilingual groups. These results show that taking the subject in English does not negatively affect the vocabulary learnt in Spanish. One issue that could explain this lack of differences is the fact that students are not confronted with the acquisition of this content for the first time. Throughout their compulsory schooling, the prompts we have surveyed have been seen in different subjects, both in primary and secondary education, so they have a previous linguistic background in Spanish.

We are not aware of other studies that have specifically analysed subject-related lexical acquisition, but the results are consistent with studies that consider the general development of L1 proficiency, in which lexis is a key element, carried out in other contexts by Bergroth [59] or Merisuo-Stomr [31] and in our context, by Barrios [32], although at different educational levels. These studies show that the fact of taking immersion or bilingual programmes does not negatively affect the L1 proficiency of students in these programmes.

However, our results do not coincide with those obtained by Herranz [54], who, like us, gives a test of availability to students of the Bachelor's degrees in Pre-Primary and Primary Education, also comparing the productive vocabulary in Spanish of the groups that take these studies in bilingual and non-bilingual modalities, and he does find significant differences in favour of the bilingual group. Although there are many aspects in common in both studies, there is one issue that may explain the lack of coincidence in the results: while Herranz surveys the traditional categories of availability studies (the human body, animals, the school, etc.), we do so on specific prompts related to the content blocks of the subject of Didactics of Matter and Energy. The fact that we are dealing with a more specialised lexicon may be the reason for these differences in the results obtained.

This absence of differences at the quantitative level is also visible when we have explored the semantic relationships through the graphs. Although we must make the caveat, as Echevarría, Vargas, Urzua and Ferreira [49] also did, that the associations cannot be considered as representative of the categories studied, due to the size of the sample, the categorisation of the Spanish lexicon is very similar in both groups, since, although we found some differences, as mentioned above, the two most clearly identifiable categories are present in both groups. Likewise, the total number of terms evoked with relations equal to or greater than 2 is slightly higher in the regular class (25) than in the bilingual class (21).

Regarding the second question on the existence of differences in the specialised lexicon in Spanish and English of the bilingual group, the results have led to the acceptance of the null hypothesis and, therefore, we must conclude that there are no statistically significant differences between the lexicon in Spanish and English as a whole, nor individually in relation to the categories analysed. This is even though lexical production is higher in Spanish than in English. That is to say that, at the lexical level, the acquisition of content has not been compromised by the fact that the classes were conducted in English. Again, although there are no studies that specifically investigate the acquisition of subject-specific lexis in bilingual teaching contexts, our results coincide with some studies [28,29], which have shown that the results in the acquisition of the knowledge content, in the context of the instruction of Natural Science subject following the CLIL approach or of Business studies in a Spanish university, have neutral effects.

As regard the words that have more than one relationship between them, we observe that the numbers are practically the same in both languages, with 22 in Spanish and 21 in English. However, from a qualitative point of view, some differences can be observed, since, as we explained above, the configuration of the lexicon is less structured in English than in Spanish, with categories fragmented into several subgroups and with less dense relations, as has already been shown in other studies comparing semantic networks in the mother tongue and in foreign languages [53,60]. This more diffuse organisation possibly makes it clear that the lexical domain is only partial [53]. Santos [60], for his part, suggests that the fields and subfields are better marked in the informants' mother tongue than in the foreign language, where both the number of words provided by the informants and the number of relations is lower, as in our study.

5. Conclusions

As we have already mentioned, this is a subject that has been little explored in the literature. Although there are studies that have investigated the lexical competence of future teachers, especially with regard to their lexical availability, this has been assessed in relation to the traditional categories of availability studies [46] or as a means of analysing trainee teachers' conceptions of education or reading, for example [42,44,47], but not by examining the specific lexis of the disciplines that make up the school curriculum and on which they are trained at the degree level. Likewise, although in the Spanish context, the study of lexical competence has aroused the interest of researchers in recent decades [61–65], they have focused on primary and secondary school students learning English as a foreign language or in CLIL programs, but there is a lack of studies that analyse the receptive and

productive vocabulary of future teachers, with the exception of the aforementioned studies of availability.

We believe that the methodology used in this study, which is based on the use of lexical availability tests for the study and representation of lexical knowledge acquired in foreign languages in non-linguistic disciplines, offers very valuable possibilities of analysis, allowing us to adequately investigate the relationships and categorisation of our students' lexical knowledge. It also provides access to students' alternative ideas about the concepts they learn, which in our study are noted but not explored in any depth. In future work, we will continue to examine this issue more extensively, extending the study sample, which can be considered, in the case of this work, as a limitation, and diversifying the content subjects under study.

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